

FIGURATIVE VERSUS OPERATIVE CUES IN THE
ACQUISITION OF CONSERVATION OF NUMBER

By

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1976

To my children, Ashley and Joshua.

May your world facilitate your development through
developmental research such as this.

ACKNOWLEDGEMENTS

Several people have earned my special appreciation for their support during the preparation and execution of this research.

Dr. Jacquelin Goldman, my chairperson, has provided both warm, supportive counsel and firm suasion throughout my graduate education and particularly during the long course of this study. Her sensitively measured portions of support and discipline have sustained my investigatory spirit. I value her friendship, wisdom, and clinical skills highly. She is a worthy and beloved mentor.

Dr. Harry Grater has also provided inspiration and support for me, particularly during my earlier years in graduate school. His teaching, supervision, and modeling, especially in the practice of psychotherapy, have shaped my perceptions and skills in important ways. His cooperation and support despite a very busy schedule are deeply appreciated.

Another very busy person who nonetheless has been supportive throughout this process is Dr. Betty Siegel. Although my contact with her has been somewhat more limited than with other committee members, her easy, genuine enthusiasm and the strong interest which she has shown in the optimum development of children have influenced me more than she knows.

Dr. Franz Epting has been one of the most important sources of inspiration regarding the potential humanness and the humaneness of

research in my graduate career. He has encouraged my initial interest in understanding and describing people as they live their lives without manipulating them extensively and artificially as so much research seems to do.

Dr. Barry Lester was a godsend after Dr. Madeline Ramey departed from the University and from my committee. Stepping in before I had completed my proposal for this research, he offered many valuable criticisms and suggestions based on his own experience with Piagetian research.

Dr. Judith Phillis and Dr. Douglas Starr, who supervise and support my work at the North Central Florida Community Mental Health Center, have offered continued encouragement and have been very understanding when my energies for work were sometimes sorely taxed by the demands of this task.

The patience and love and very hard work of my wife Sandra were absolutely essential factors in the completion of this research. She has provided unwavering support for me in this task in spite of the demands of her job and her roles as wife and mother.

Finally, in moments of greatest despair, the joyful smile and trusting love of my daughter Ashley have warmed and energized me and renewed my sense of the worth of children in human life and its struggles.

I would be seriously neglectful if I did not express my deep gratitude to the principals, teachers, children, and parents of Littlewood Elementary School, Metcalfe Elementary School, P.K. Yonge Laboratory School, Andromeda School, and Mother Goose Nursery. Without their participation, the research would not have been possible.

TABLE OF CONTENTS

	<u>Page</u>
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vii
ABSTRACT	ix
INTRODUCTION	1
Operative Aspects of Knowledge.	3
Sensorimotor period.	3
Preoperational period.	7
Period of concrete operational thinking.	12
Figurative Aspects of Knowledge	16
The nature of perception	17
The origin and development of perception	19
The function of perception	23
Comparison of Operative and Figurative Aspects of Knowledge	24
Conservation of Number.	26
Criteria for judging the presence of conservation.	28
Criteria for judging the level of initial cognitive development.	30
Components of conservation	31
Hypotheses.	38
METHOD	41
Subjects.	42
Procedures and Materials.	44
Screening.	44

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
Pretests for conservation.	48
Criteria for determining the initial level of cognitive development.	49
Posttesting for conservation	51
Planned experience in conservation of number	52
Controls for experimenter bias	56
Judgment of the adequacy of responses.	57
RESULTS.	58
Interjudge Agreement in Classifying Subjects' Responses . .	58
Analysis of Dependent Variables	59
Rationale for nonparametric analysis	59
Experience group effects	63
Effects of initial level of cognitive development. . .	79
Summary of hypothesis testing.	79
DISCUSSION	81
APPENDIX A -- MATERIALS AND PROCEDURES FOR SCREENING TO ASSESS BASIC CONCEPTS	90
APPENDIX B -- DISPLAYS FOR RECOGNITION OF NUMBER EQUIVALENCE . .	94
APPENDIX C -- DISPLAYS FOR CONSTRUCTION OF NUMBER EQUIVALENCE. .	96
APPENDIX D -- MATERIALS AND PROCEDURES FOR PRETESTS OF CON- SERVATION.	97
APPENDIX E -- PROCEDURE FOR THE HIGH OPERATIVE CUES EXPERIENCE .	100
REFERENCES	103
BIOGRAPHICAL SKETCH.	106

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1 Demographic Characteristics of the Sample by Level of Cognitive Development and by Planned Experience Group. . .	43
2 Items Used in Planned Experience Groups for Conservation of Number.	53
3 Means (M) and Standard Deviations (SD) of the Number of Correct Judgment and Explanation Conservation Responses.	60
4 Means (M) and Standard Deviations (SD) of the Number of Correct Judgment Only Conservation Responses	61
5 Means (M) and Standard Deviations (SD) for Number of Trials to Acquisition of Conservation of Number.	62
6 Frequency Distributions of Raw Scores for the Conservation of Number Posttests -- Judgment and Explanation . . .	64
7 Comparison $\bar{z}$ Scores for Experience Groups for Conservation of Number -- Judgment and Explanation	66
8 Frequency Distributions of Raw Scores for the Conservation of Number Posttests -- Judgment Only.	68
9 Comparison $\bar{z}$ Scores for Experience Groups for Conservation of Number -- Judgment Only.	69
10 Frequency Distributions of Raw Scores for the Conservation of Length Posttests -- Judgment and Explanation . . .	70
11 Comparison $\bar{z}$ Scores for Experience Groups for Conservation of Length -- Judgment and Explanation	71
12 Frequency Distributions of Raw Scores for the Conservation of Length Posttests -- Judgment Only.	73
13 Comparison $\bar{z}$ Scores for Experience Groups for Conservation of Length -- Judgment Only.	74
14 Frequency Distributions of Raw Scores of the Conservation of Liquid Posttests -- Judgment and Explanation . . .	75

LIST OF TABLES
(Continued)

<u>Table</u>		<u>Page</u>
15	Frequency Distributions of Raw Scores for the Conservation of Liquid Posttests -- Judgment Only.	76
16	Frequency Distributions of Raw Scores for Number of Trials to Acquisition.	77
17	Comparison <u>z</u> Scores for Experience Groups for Number of Trials to Acquisition	78

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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By

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December, 1976

Chairperson: Jacquelin R. Goldman
Major Department: Psychology

Sixty children, ages 45 to 88 months, participated first in a screening procedure designed to ensure their understanding of basic relational terms and concepts, determine their ability to conserve, and classify the children into levels of cognitive development. Then, nonconservers and intuitive conservers were assigned randomly to one of three planned experience groups. The High Figurative Cues experience used minimal cognitive cues and enhanced perceptual cues. The Control group experienced the same low cognitive cues as the High Figurative Cues group with minimized perceptual cues as well. The High Operative Cues experience included minimal perceptual cues with enhanced cognitive (operative) cues in the form of verbal rule instruction and sensori-motor rehearsal. After participating in their respective planned experiences, all children were posttested immediately and after 10 to 14 days for conservation of number, length, and liquid.

Three hypotheses were tested. First, intuitive conservers should have achieved higher scores than nonconservers on both immediate and

delayed posttests. Second, because highly salient perceptual cues have been identified as distracting and verbal rule instruction and behavioral rehearsal have been identified as facilitative, the High Operative Cues group should have achieved the highest scores of the three experience groups; the Control group would have earned intermediate posttest scores; and the High Figurative Cues group would demonstrate the lowest posttest scores. Finally, it was predicted that intuitive conservers would require fewer trials to acquire the conservation concept than nonconservers and that the High Operative Cues group would require the fewest trials among the planned experience groups.

A multivariate extension of the Friedman nonparametric analysis of variance was used to analyze the data with two different criteria for defining a conserving response -- judgment with explanation and judgment only. Hypothesis 1 received no support. Hypothesis 2 was partially supported. The High Operative Cues group produced a distribution of significantly higher scores using judgments with explanations and using judgments only for conservation of number on the immediate posttest than did the High Figurative Cues or Control groups and a distribution of significantly higher conservation of number scores on the delayed posttest than the High Figurative Cues group for judgment-with-explanation conservation. For conserving responses using judgment only, scores for the High Operative Cues group were significantly higher than scores of either the High Figurative Cues group or the Control group on the delayed posttest. There was no significant difference between the distributions of the High Figurative Cues group and the Control group for conservation of number responses using either

criterion. The distributions of conservation of length responses using both judgments with explanations and judgments only were also higher for the High Operative Cues group than for the other two experience groups on the immediate posttest. The delayed posttest for conservation of length demonstrated higher scores for the High Operative Cues group than for the Control group for both judgment-with-explanation and judgment-only responses. Again, there were no significant differences between the High Figurative Cues and Control groups. Finally, the first part of the last hypothesis was not supported, but the second part was supported.

Results confirmed previously demonstrated effectiveness of experience with relevant cognitive cues. There was no support for the expectation that with minimal supportive cognitive cues in the Control group and the High Figurative Cues group, the enhanced perceptual cues in the High Figurative Cues experience would interfere with acquisition of the concept of conservation.

INTRODUCTION

In his efforts to define and explain the ontogeny of individual knowledge, Jean Piaget has described two interdependent systems through which people acquire knowledge about their universe -- an operative system of knowing and a figurative system of knowing. The operative system consists of early sensorimotor behaviors which are the foundation for rational intelligence and of later representational and rational intellectual operations. The figurative system of knowing includes perceptual processes, mental imagery, and memory. Research usually centers on one system or the other. Yet in theory, Piaget and his colleagues (Piaget, 1967; Piaget, 1969; Piaget & Inhelder, 1969) have underscored the interdependence of figurative aspects and operative aspects of knowledge. Recently, American researchers (Youniss & Dennison, 1971) have successfully demonstrated such interdependence of figurative and operative aspects of knowing in a single but precise study. In an attempt to discover the relative contributions of figurative structures and operative structures to the development of rational thinking, the present research has been designed to explore the contributions of figurative and operative systems of knowledge to the acquisition of conservation of number, one of the early forms of operational thinking.

Piaget's most concise statement about the relationship between figurative and operative aspects of knowledge is found in his concluding

chapter of The Mechanisms of Perception (1969):

One might begin by saying that an operative system of transformations consists in reciprocal changes between states and that these states can only be characterised as configurations: thus the figurative aspect of knowledge would indicate the existence of, or represent, the perceived states of objects or events, while the operative aspect would have to do with their transformations. Both aspects would be mutually indispensable at the level where their unity becomes inevitable, but on the basis of a subordination of configurations to transformations: if the figurative aspect were left to itself and had to rely on its own capacities, it would give rise to all sorts of systematic illusions, being centred on the states of objects and lacking the corrective decentrations of transformations. (p. 357)

The summary emphasizes three significant facets of the relationship between figurative and operative aspects of knowledge. First, the two systems are distinguished as functionally separate. The figurative phase of knowing represents immediate states using sensory data organized by perceptual schemes. Operative knowledge, on the other hand, represents transformations, actions on the object which modify the object either externally and physically or internally and deductively. Second, the two aspects of knowing are "mutually indispensable." Especially during the development of knowledge from birth through young adulthood, the ontogeny of knowing is dependent on the interaction of figurative and operative aspects of knowledge (e.g., Youniss & Dennison, 1971). Prior to the maturation of formal operational thinking which permits the individual to manipulate thoughts themselves as a part of thinking, that is, to think about thinking, the individual can only deal cognitively with those objects or events which are perceived immediately or have been perceived as objects or events in reality. In fact, even beyond the full acquisition of propositional (formal operational) thinking, an individual must continue to deal with concrete

objects and events throughout his lifetime; consequently, the interaction between configurational and operative systems continues to occur. Finally, Piaget's summary statement points out his belief that the operative aspects of knowledge are superior to the figurative aspects. For Piaget the superiority is both developmental and structural. Sensorimotor intelligence, the first phase of cognitive development, is a necessary precursor and foundation of organized perception. Intellectual structures, at first similar in some ways to figurative structures, soon surpass the latter in complexity and flexibility. Because of the superiority of operative structures, many of Piaget's descriptions of figurative structures are worded by contrasting and comparing the latter with the former. Consequently, the first three (of four) phases of operative development will be presented now with the hope of providing a more lucid context within which to understand figurative development.

Operative Aspects of Knowledge

The operative aspects of knowledge are the sensorimotor activities of infancy, the preoperational representations of early childhood, and the later logico-mathematical operations; that is, concrete operations and formal operations. In order to emphasize the operative nature of the phases of intellectual development, the following section will present some of the operative features of the first three periods of the development of intelligence.

Sensorimotor period. The first major period of cognitive development, lasting from birth to two years, is known as the sensorimotor period. Sensorimotor intelligence is a practical, behavioral

intelligence primarily functioning without language or representative concepts. The sensorimotor behaviors are essentially adaptive and are aimed at getting results rather than communicating truths (Piaget & Inhelder, 1969). The development of intelligent behaviors is dependent on the child's manipulation of objects and events in his environment as well as on his active structuring of the interaction between himself and the objects or events which he encounters and then works to reconstruct. These two essential levels of activity are not distinct for the young child but are united in a hypothetical cognitive structure known as sensorimotor schema (Piaget, 1952b) or as an action-scheme (Piaget & Inhelder, 1969) -- a total act of intelligence. In the beginning the act is the act, that is, an undifferentiated entity in which personal consciousness (self) is not distinct from the external world, perception is not separate from movement, and the incorporation of new behaviors into the action-schemes (assimilation) is inseparable from the modification of the schema itself to bring it in line with data from the real world (accommodation). The child is completely egocentric, seeing the world from a single point of view, without knowledge of the existence of alternate perspectives and without awareness that he is imprisoned by his own singular perspective (Flavell, 1963). However, by the end of the sensorimotor period, differentiation is well advanced. The progression of sensorimotor intelligence leads to the child's awareness of the distinction between objective reality, where his body is one of many distinct elements, and his personal internal construction or representation of that reality. With the achievement of greater objectivity near the end of this initial period of intellectual development, perception and movement

as well as the processes of assimilation and accommodation gain the capacity to coordinate with and to complement one another in intelligent action.

The young infant's mental life consists of early sensory and motor behaviors that respond to basic needs such as nutrition. With the exercise of these early behaviors, change occurs in the form of elaboration because the behaviors do not merely repeat themselves exactly. The repeated actions may include an additional movement or may focus on a different object in the child's environment. The additional movement or the new object are then incorporated into the existing behavior scheme to create broader organized totalities of action (Piaget, 1967). With increasing behavioral facility, the infant begins to notice the results of his own behavior. The random movements often fortuitously produce a result so interesting that he repeats the movements immediately, varying the actions and noticing the results of the variation. The immediate repetition of behavior has been labeled a "circular reaction," and it comprises true exploration, the first "experiment in order to see" (Piaget, 1967, p. 11). As behaviors are repeated and expanded through variation, the infant's perceptions and movements become more differentiated and better organized. The processes of assimilation and accommodation begin to complement one another. Action schemes with similar content or focus begin to combine into more complex action schemes which coordinate and relate the differentiated and generalized behaviors of the component schemas. This capacity to form new, complex, and more comprehensive relationships among behavior even without language is a crucial operative achievement during the sensorimotor period.

The coordination of action-schemes and the capacity to generate relationships is a significant milestone in itself, yet it leads to a second important achievement by the end of the sensorimotor period of intellectual development, namely, the differentiation of self from other entities in reality. Piaget summarizes this achievement in the first of his Six Psychological Studies (1967). The child's impressions are not clearly associated with a personal consciousness or with external objects. Impressions "exist in a dissociated block ... on the same plane, which is neither internal nor external but midway between these poles" (Piaget, 1967, p. 12). The result of this dissociation is an unconscious egocentricity with "self" as the necessary referent in experience. But the development of sensorimotor intelligence allows the child to eventually structure an objective universe in which the child is one object among others in reality. And with the developing sense of self, the differentiation of internal and external states evolves.

From the child's general progression from egocentrism to objectivity, it is a small step to consideration of a facet of sensorimotor development which is an important precursor of the rational concept of conservation. Developing objectivity allows a child to recognize the invariance of some important dimension of an object in the face of certain changes in other dimensions. This aspect of sensorimotor development is known by either of two phrases the object concept or object permanence. Piaget lists several characteristics which essentially define a mature object concept. First, the object must be seen as an entity independent of the self as object and observer. Second, the object must be construed as independent of the immediate activity,

i.e., observing, manipulating, etc., which the child may apply to it. Finally, full maturation of the object concept implies recognition of the self as an object sharing the above properties and always existing among other objects (Flavell, 1963).

Preoperational period. The hallmark of the second major period of cognitive development, the preoperational period, is the achievement of thought itself. During this period, which lasts from the second year until about the sixth or seventh year, the child advances from time-bound, overt, sensorimotor acts to the inner, symbolic manipulation of reality which "allows him both to reconstitute the past (to evoke it in the absence of the objects which were previously acted upon) and to anticipate future, not yet executed, actions to the point where sometimes actions are replaced by words and are never actually performed" (Piaget, 1967, p. 22). In an important behavioral achievement of this period, representational thought can consider action rather than merely acting immediately or impulsively. In the delineation of the periods of operative development, the accomplishments of this period stop short of logical thought. The preoperational period, then, encompasses the evolution of intelligence from pragmatic, organized, and usually purposive actions to prelogical symbolic-representational thinking.

Representations replace overt actions as the basis of adaptive functioning when the child achieves what Piaget has termed the symbolic function (Piaget, 1951, p. 69). The symbolic function is simply the ability to differentiate a signifier from an object or event that is being signified (known as the significate). Achievement of the symbolic function requires an awareness of the separateness of the signifier and the thing signified. Describing the most important and

most common signifier, Baldwin (1967) notes,

a word does not function as a sign for the object it represents unless the person using the word realizes what the word means and also realizes that the word is not the same as its meaning. It is this ... criterion that excludes perceptions and sensorimotor schemas from the class of symbolic schemas. (p. 230)

According to Piaget, the child acquires the symbolic function through particular developments in assimilation and accommodation. As accommodation matures, one of its most important developmental products is imitation, an active modeling or replication of an original external event. During the sensorimotor period this imitation is simply an overt act mimicking or reproducing the event. With growth and refinement, however, the child develops the capacity to imitate an event internally as well as externally. Shortly thereafter, the child also becomes capable of imitating reality from memory even though the event has ceased to exist in perception. Piaget refers to this capacity as "deferred imitation." Such an achievement extends the time boundaries of the child's intellectual functioning beyond the immediate present. Piaget surmises that accommodation-as-imitation thus supplies the very young child with his first signifiers which are capable of representing an absent significate for him internally. The signifiers are mental images which he may now evoke in thought, rather than acting out in reality, as imitations made in the past. According to Flavell (1963), the capacity to evoke signifiers allows the child to anticipate events and thus direct future action. Past images are evoked internally in the present and serve as "anticipative mediators of actions not yet performed" (p. 153).

The role of assimilation in the symbolic function is somewhat less complicated though equally significant. With the elaboration and

distillation of the assimilation function, play emerges as its product and primary mode of expression. Play, like its parent function, alters reality to suit the history and the needs of the self. Whenever a child pretends, there is no urgent need either for the objects used to resemble the pretended objects or for the pretense of behavior to be convincing or come to some final conclusion. The child may substitute whatever objects are at hand for the represented original objects, and he may stop the game whenever he likes. Nonetheless, symbolic play does have a crucial function in the development of thought. Piaget (1967) asserts, "Practically every form of psychological activity is initially enacted in play" (p. 23). Through play, reality is incorporated into schemas to provide external referents and, thus, meaning for the signifiers supplied through accommodation. Consequently, representation is a result of a differentiated, complementary partnership between accommodation (imitation) and assimilation (play).

Being concerned primarily with the nature of operative aspects of knowledge, the present discussion of the preoperational period would be inadequate if it ended with the simple summary of the symbolic function and representation. A number of features of preoperational thought should be noted carefully in order to clarify the meaning of operative functioning. These essential features will be presented as shortcomings of preoperational thought which mark the cognitive achievements of this period as incomplete forms of reasoning. First, the intuitive thinking which is the highest intellectual accomplishment of this period is still bound by particular past or present configurations. The complexity of the configurations represented by preoperational thought has increased over the simple individual image

represented in the most rudimentary thought at the end of the sensorimotor period. But reasoning is still not free to proceed without a specific original past or present image. Preoperational thinking is often in the form of what Piaget terms a mental experiment, "an isomorphic, step-by-step mental replica of concrete actions and events" (Flavell, 1963, p. 158). Second, preoperational thought continues to demonstrate profound egocentricity, that is, the child is unable to take the role of another person or to see his own perspective as one of several possible points of view. A third characteristic of preoperational thought is its tendency to center attention on a single, striking aspect of a configuration to the neglect of other important aspects of the figure or event during the process of reasoning. As one might infer, the neglect of important aspects of an event or configuration often will lead to systematic error or distortion. More advanced operational thinking is able to decenter, that is, to attend to multiple facets of an object of thought and to coordinate all features in order to minimize error or distortion in reasoning. Fourth, the child considers the successive states or configurations of a display much like viewing motion picture film one frame at a time rather than the transformations relating the states to one another as a total process. The child at this point in development cannot consider the process linking successive states with continuity, thus preoperational thought is static, immobile, and impressionistic. Fifth, the precepts of preoperational cognition demonstrate two peculiar characteristics. The meaning of these precepts fluctuates with a changing context; they have no intrinsic identity which is stable across situations. And the precepts are linked by a primitive reasoning

which moves from one centered, perceptually-compelling feature to another. The conclusions are thus often based on salient perceptual features which occur juxtaposed to other perceptual features and which end the preconceptual reasoning because they appear last in the sequence. Reasoning is transductive and moves from particulars to particulars. It is more often incorrect than correct. Finally, and most significantly for Piaget, preoperational thought is not reversible. Reversibility is the ability to proceed through a cognitive sequence in one direction and then reverse direction in thought to retrace the steps of the reasoning back to the original premises which are constant and unchanged. By simply capturing concrete mental images of real events which are usually unidirectional in daily experience, preoperational thought lacks the capacity and initiative to return logically to the starting point of the event. The quality of irreversibility also means that children in this phase of cognitive development cannot conserve a particular property of a stimulus array, such as number, weight, or volume, as invariant in the face of compensating dimensional changes (e.g., increase in height with decrease in width of a container). Preoperational reasoning is confined to concrete images derived from successive perceptual states. Consequently, the child whose thinking is characterized by preoperational reasoning is unable to undo mentally the changed state or dimension by using its inverse to discover the invariance of the crucial property.

Piaget (1951) summarizes the advancement of representational preoperational thinking by characterizing representation as extending the field of adaptive behaviors beyond present time and space. Thus the child can deal with what lies outside of immediate perception and

action. Representation is the product of the signifier, which is supplied by internal imitation (accommodation) which permits recall, and the significate, which is supplied by assimilation and provides meaning for the signifier. "In this respect, the collective institution of language is the main factor in both the formation and socialisation of representations" (Piaget, 1951, p. 273).

Period of concrete operational thinking. The highest cognitive achievement during middle childhood (roughly 7 to 11 years) is concrete operational thinking. It is worth noting that this period has been studied more frequently than any other Piagetian period of intellectual development. This is due at least partly to the fact that increasing verbal facility and increasing cognitive flexibility render children at this level of development more testable than younger children. The present study thus has joined a large number of investigations into the nature of concrete operational thought and especially the subset of research investigating the inducement of concrete operational thought in the form of conservation.

What is the essence of concrete operational thinking? According to Flavell (1963),

If we look with the Piagetian eye, we see one higher-order difference which subsumes all the particulars; and from this one difference stems most of what Piaget has to say about the subperiod of concrete operations: It is simply that the older child seems to have at his command a coherent and integrated cognitive system with which he organizes and manipulates the world around him. Much more than his young counterpart, he gives the decided impression of possessing a solid cognitive bedrock, something flexible and plastic and yet consistent and enduring, with which he can structure the present in terms of the past without undue strain and dislocation, that is, without the ever-present tendency to tumble into the perplexity and contradiction which mark the preschooler. (p. 165)

One significant implication of this indispensable system is that no operation exists in isolation; any operation is formed by and derives from a structured system of operations of the same kind such as class operations, arithmetic operations, geometric operations, etc. The system is the sine qua non of cognitive operations, whether formal (propositional) or concrete.

In keeping with the heritage begun during the sensorimotor period of intelligence, the content of the cognitive system central to operational intelligence consists of actions performed by the child. Discussing the mental development of the child, Piaget (1967) has stated, "Psychologically, an operation is, above all, some kind of action (the act of combining individual or numeric units, displacing them, etc.), whose origin is always perceptual, intuitive (representational), or motoric. The actions which are the starting point for operations are thus rooted in the sensorimotor schemata, i.e., in actual or mental (intuitive) experience" (p. 48). Piaget's use of the term "action" in his theorizing is, of course, generic. Its meaning is altered slightly with each successive stage. During the sensorimotor period, action refers to overt, observable behavior. The preoperational representations are the initial internalized actions; but they are sporadic and idiosyncratic, not organized into tight ensembles of related action, and are still bound to immediate perception. The actions of operational thought are more abstract and internalized than the actions of the previous periods, but the crucial fact at this point is that the actions form "increasingly complex and tightly integrated systems of actions" (Flavell, 1963, p. 165).

Piaget derived his models for explaining how concrete operations

function from the fields of logic and mathematics. These logico-mathematical structures were postulated as ideal models of human reasoning. The logical structures which direct concrete operational thinking are known as groupings. There are nine groupings covering the concrete operations for logical classes and for relations. Each of the groupings has in common five major properties. The form (equation) in which each property is expressed varies among the groupings, but the basic properties are universal. The logico-mathematical nature of concrete operations is apparent in the five basic properties which are described below:

1. Composition. When any element is combined with another element by means of a defined operation (addition or multiplication), the product of that combination is itself an element in the system of classes or relationships.
2. Associativity. The sum or product of a series of elements is independent of the way they are grouped in the equation.
3. General identity. The identity element is the one and only element which, when added to or multiplied with any other element whatsoever, leaves the other element unchanged.
4. Reversibility. For each and every element there is one and only one inverse element which yields the identity element when it is added to or multiplied with that unique element. Two kinds of reversibility operate in the groupings. Inversion or negation, where $+A$ is reversed by $-A$, is the inverse operation for classes. Reciprocity, where $A < B$ is reciprocated by $B > A$, is the inverse operation of relations.
5. Special identities. Each of the groupings has special elements which, in special circumstances, may also function as identity elements. (Flavell, 1963)

Each of these five properties is necessary for construction of an operational system of actions.

Nevertheless, in Piagetian writings which have been translated into English and in American research of Piagetian theory, one of these properties has received an inordinate amount of attention. That

property is reversibility. As an essential characteristic of operational thought and, hence, of operative knowledge, several things are known about the role of reversibility in logical thinking. First, it is significant to recognize that reversibility allows the child to extend his cognitive functioning beyond perceptible states of the environment to include the transformations which produce and relate successive states. Reversibility is a necessary condition for the child's comprehension and use of transformations inherent in a logical system of actions. Further, with the advent of reversible operations, the child achieves the ability to compensate for changes in his environment in order to recognize its invariant features. Thus he can observe or imagine actual changes in the environment and also compensate for complementary changes by imagining the transformations in an inverse sense. The reversible transformation thus always leaves some feature of an operational system unchanged; otherwise, it would be irreversible. In the conservation experiments, the constant invariant feature is the conserved quality.

The summaries of the first three periods of operative development are now complete. Sensory-motor intelligence, preoperational representational thinking, and concrete operational thought have been presented briefly in order to provide an explanation for and description of the cognitive functioning of the children studied in the present investigation. Concrete operational thinking is the upper limit of cognitive maturity in the children who are tested and trained in the conservation of number. However, in order to provide some sense of closure for the discussion of intellectual development, a quotation will be borrowed from Flavell to summarize the essential achievement

of the ultimate stage of cognitive functioning -- the period of formal operational thought. According to Flavell's (1963) description,

The most important general property of formal operational thought ... concerns the real versus the possible. Unlike the concrete-operational child, the adolescent begins his consideration of the problem at hand by trying to envisage all the possible relations which could hold true in the data and then attempts, through a combination of experimentation and logical analysis, to find out which of these possible relations in fact do hold true. (p. 204)

Thus formal thought is no longer limited to concrete reality and becomes hypothetico-deductive (allowing "if ... then" reasoning), propositional (proposing statements about raw data and manipulating those statements rather than the data themselves), and capable of systematically isolating all individual variables and assembling these variables in different combinations for careful consideration, all without distorting the totality of the system. In short, instead of thinking of perceptions or motoric actions, the adolescent can think about thoughts themselves and about the transformations which relate these abstract "actions."

Figurative Aspects of Knowledge

Piaget's (1969) statement about operative and figurative aspects of knowledge appearing early in this introduction contains the closest approximation to a one-paragraph definition of figurative aspects of knowledge available in English translations of his work. The reader may recall that he depicts the figurative aspects of knowledge as indicating "the perceived states of objects of events" (Piaget, 1969, p. 357). Therefore, perceptual processes serve as the focus of the

discussion of figurative knowledge. In discussing perception as the primary example of figurative aspects of knowledge, it is useful to recognize the distinction made by Flavell (1963) between the Piagetian theory of perception and Piaget's theory about perception. His theory of perception consists of a precise, probabilistic model of actual perceptual apparatus and its functioning. His theory about perception is a general conception of perception and its development, particularly in relation to the nature and development of intelligence. Because the present study explored the impact of figurative and operative experiences on the development of operative structures, specifically conservation of number, the discussion centers on Piaget's theory about perception and mentions the model of perception only as it contributes to understanding the relationship between perception and intelligence. The ensuing discussion presents perception by dividing the construct somewhat arbitrarily into three aspects: the nature of perception, the origin and development of perception, and the functions which perception fulfills.

The nature of perception. At the risk of overstating the obvious, the consideration of the nature of perception should begin by recognizing that Piaget views perception as an aspect of knowledge which is separate, although not completely autonomous, from intelligence. This view is reflected both in the abundance of research published by Piaget and his associates in the series entitled "Recherches sur le developpement des perceptions" in the journal Archives de Psychologie and in his own explicit statements (e.g., Piaget, 1969, p. 338). Equally important for an adequate understanding of Piagetian theory about perception is an awareness of the two kinds of visual perceptual

phenomena -- primary perception and perceptual activities. Primary perception refers to centered visual fixations "which do not involve any eye movements and which exist in a single field of focus" (Piaget & Inhelder, 1969, p. 35). Developmentally, primary perception remains relatively constant with age and is studied (and operationally defined) by means of tachistoscopic presentation with exposures lasting from .05 to .20 seconds. Perceptual activities, which develop in quantity and quality with age, involve shifting one's fixations in space in visual exploration or comparing two stimuli which may appear in the same place at different times. With some awareness of these two perceptual processes, two other characteristics of perception are perhaps more easily understood. First, Piaget views perception as an active process rather than a passive reception of raw sensations. The child determines what he perceives, albeit often unwittingly, by the spot of the stimulus chosen for fixation in primary perception or by the extent to which he shifts fixations and the areas of the stimulus viewed via perceptual activities. Centration and decentration are two terms used to describe the actions of perception. Centration refers to fixations on a single salient perceptual aspect of a stimulus array to the exclusion of other aspects. Decentration is the descriptive label for shifting fixations in the form of exploration, transposition, or extension. Perception thus constitutes real activity for the child. Second, perception is always probabilistic in nature. Piaget and Inhelder (1969) explain,

In looking at a configuration, even a very simple one, only a small area can be clearly seen in each single glance. One does not in fact see everything with the same precision, and one does not see everything at the same time. The gaze moves from one point to another, and the "encounters" between the different parts of the receptive organs and the different parts of the

stimulus object are distributed with unequal density according to the regions of the figure, the regions of the retina, and whether at a given moment these regions are centered by the fovea ... or remain in the periphery. (p. 36)

Perception is therefore probabilistic in the sense that all elements of an object will not be viewed with equal precision, frequency, duration, or intensity; consequently, those elements which capture the child's attention and are observed with greater precision, frequency, duration, and intensity will be more likely to determine the nature of perception's often incomplete, global evaluation. Finally, perception is impressionistic. "Perception provides only instant impressions corresponding to a given view point (that of the subject at a given moment), whereas the concept presupposes a coordination of all viewing points and an understanding of the transformations leading from one viewing point to another" (Piaget & Inhelder, 1969, pp. 45-46).

The origin and development of perception. Another index of the status of perception within Piagetian theory and especially of the relationship between perception and conception is discovered in the discussion of the origin and development of perception. As indicated earlier, Piaget believes that perception is developmentally inferior to intelligence. Consequently, his discussion of the origin and development of perception is couched in terms of the comparison-contrast of perception and intelligence (e.g., Piaget, 1969; Piaget & Inhelder, 1969). Piaget consistently asserts two strong convictions about perception. First, perception is distinct as an epistemological process. And second, the perceptual process represents a particular aspect of sensorimotor organization which serves to enrich the action-schemes and is dependent on sensorimotor action-schemes for meaning.

The relationship between perception and intelligence is construed in this way because perception is conceptually a more limited process in Piagetian theory than it is for many psychologists. Perception involves instant, impressionistic judgments or inferences. Perception's organization of successive isolated configurations into perceptual schemas occurs with essential assistance from sensorimotor actions which direct the manipulation of the objects (e.g., drawing, constructional games, etc.) to establish multiple perceptual experiences with the same object and to reveal the correspondence between elements of perceived objects. Although Piaget repeatedly emphasizes the individual identity of perception and intelligence, perceptions are generated, along with new motor skills, from the varied repetition of the earliest behaviors. In short, perception emerges from the earliest form of action; and its development subsequently is guided by acts of intelligence from that moment.

Although the origin of perception happens with the occurrence of the first actions, the development of perception is precocious; that is, certain perceptual phenomena precede intellectual operations and forecast their eventual development. Piaget suggests that the perceptual (figurative) phenomena prefigure the operational notions. The operational notion of conservation will serve as an example of prefiguration. The precursor of operational conservation is the sensorimotor schema of the permanent object which emerges with the elaboration of the perceptual constancies -- constancy of size and constancy of form. These perceptual constancies are based on a crude system of compensations which are also necessary in a more elaborate form for conservation.

The constancies prefigure conservation in the sense that both are based on the same functional process of compensation. Moreover, the common process produces a common product -- the invariance of a particular quality despite change in salient aspects of objects or events. The process consists of three factors: a, b, and c. For both perceptual constancies and conservation, factor c is the invariant factor that emerges as the product of compensation between a and b. However, in keeping with the inferior nature of perception as a basis of knowledge, there are important differences between the nature of the component factors, a and b, as they function first in the more primitive perceptual constancies and later in the operational notion of conservation. For the constancies, the first factor, a, is a deforming factor, an objective modification of the system such as real changes in physical distance between objects in perception of size and real changes in perspective (location) in the perception of form. The second factor, b, is a deformed factor, a subjective modification of the system such as apparent size or shape. Factor c, then, is the perceived invariance of the object in real size or form despite the change in real distance or location (perspective). The objective change is thus compensated by the subjective change through a system of approximate perceptual readjustments. For conservation, both factors a and b are objective changes in the system, and the invariant factor c is the product of the compensation between objective factors a and b. For example, in the case of conservation of number, factor a is the length of the row, factor b is the density of the elements, and c is the number of elements in a collection. Length of a row (a) may increase; but if density (b) decreases, then the number of

elements (c) will remain the same.

Piaget explains the precocity of perceptual constancies by observing that the object itself is never physically changed but gives rise to a subjective modification because it is moved relative to the observer. According to Piaget (1969), the apparent change (b) is more easily compensated by the person's perception of the deforming factor (a) because the perception is a property of the system relating the object to the subject. The compensation is accessible to perception and can occur through successive approximate perceptual changes. The perceptual compensation is based on the experienced invariance of the object as the person exercises action-schemes in which the apparent quality (strictly perceptual) is modified during the perception of real changes in the relationship between the object and the subject because of the object's movement. Perceptual constancy thus involves only a single change in the object itself along with a change in the person's perception. Conservation, on the other hand, involves modification of two salient qualities of the object itself, simultaneously. Consequently, recognition of the invariance of the constant factor occurs only when the child can represent each objective modification independently and hence can manipulate the qualities in a reciprocal relationship. Piaget (1969) concludes, "the representational readjustments give rise to a system of genuine operations whose strict reversibility, in turn, engenders ... strict invariance characterized by its deductive necessity and not by probabilistic approximations" (p. 328). In summary then, after a delayed start, perception develops rapidly, actually reaching its zenith late in the period of representational thought. Intelligence, emerging from early behaviors, follows a

separate, more deliberate course of development which does not achieve its culmination until early adolescence but which surpasses perception in accurately guiding adaptive behavior with the achievement of operational thought.

The function of perception. Finally and very significantly, perception functions as the second of the two fundamental forms of adaptive human behavior, the other being intelligence. This form of adaptive behavior prefigures its superior and forecasts its eventual operational functioning in two ways. First, as transformations eventually relate objects and events and their changes through complex operations, perceptions connect the early transformations as states between the transformations. Piaget (1969) states quite clearly that existing in the here-and-now, perceptions function as connectors which establish immediate and constant contacts between the child's actions or operations and the events or objects. These figurative aspects of knowledge are organized by the person, through perceptual activities, into configurations which are compatible with the transformations. The configurations in turn can be used as links between transformations within a coherent operational system. "A result is the apparent prefiguration of operational notions in perception" (Piaget, 1969, p. 360). The second forecast of operational functioning by perception involves the gradual increase in the child's ability to decenter and thus to consider successive centrations or fixations as a way of correcting the distortions or errors of centered perceptions. Although perceptual decentration does not develop as completely as decentration in operational thinking and never achieves the accuracy and objectivity of operational thought, its growth is a necessary condition for maximum

perceptual adaptation and presages the ability of operational thinking to move from one perspective to another in considering logical alternatives. Piaget sees decentering perception as a constructive process of gathering as much information as possible about an object. Thus perceptual decentration expands the amount of information available and the child's ability to coordinate the increased information in the process of construing perceptual schemas. In reflecting on the functional role of perception, the reader should realize that prefiguration only implies earlier appearance and not causation. The developmental similarities between precocious perception and operational thought are collateral but not formative. Beginning with sensorimotor actions, perceptual activity must be integrated with and directed by actions. Intellectual actions or operations do not replace perceptions, but they do program the way perceptual data are collected. With the advent of operational intelligence, the child often substitutes a science of measurement for global perceptual evaluations (Piaget & Inhelder, 1969).

Comparison of Operative and Figurative Aspects of Knowledge

In summarizing the discussions of operative and figurative aspects of knowledge, several characteristics distinguish the two modes of acquiring knowledge about the world and about oneself in the world.

First, the actions constituting operative knowledge often produce or participate in change. The active manipulation of elements in the environment, either physically or mentally, will modify the elements themselves and often subsequently undo the original modification. In

the process the child will discover the key to creating new objects or events by transforming the immediate environment. The essential quality is the ability to discover the world through environmental manipulation. Further, operative knowledge at its peak is not limited by time and space. Formal operational thought functions with past, present, and anticipated elements, some of which may not even exist in the present reality. Likewise, formal operational thinking can move beyond the limits of the senses, however well-organized, to the limits of outer and inner space. Thirdly, operative aspects of knowledge enjoy the flexibility of reversibility, that is, the ability to return to the origin of a concept instantly despite elaboration of the concept and know that the original remains unaltered. It is interesting to note that although formal operational thought is able to function well without immediate perception and is no longer necessarily dependent on perception, those who have achieved the ultimate operative cognitive capacity continue to employ perception as the link between new objects and events and corresponding actions or operations.

In contrast, we find that figurative aspects of knowledge at the zenith of their development cannot escape their dependence on the operative mode of knowing for the focusing of attention on relevant elements and thus the programming of perceptual organization. Viewed as an active knowledge, figurative activity is nonetheless restricted to recording and preserving events rather than producing them. The active figurative processes consist of data-gathering through the movement of sensors, not objects in the environment or the environment itself. In addition, figurative aspects of knowledge suffer spatial and temporal limits in their functioning. Operating most frequently

in the present within the range of human senses, figurative aspects of knowledge have a restricted capacity to recall past events and no ability to foresee or anticipate future events. Finally, configurations are mostly irreversible because retracing perceptions step-by-step to the original often produces a perception which has been slightly reorganized by succeeding perceptions.

Conservation of Number

Within the broader theoretical context outlined above, consider the focal task of the study -- conservation of number. Although it has served as an example in the discussion of concrete operational thought, the concept of conservation needs more precise definition. Conservation denotes the child's realization of the substantial invariance of a particular dimension of a stimulus object or a collection of objects despite change in other perceptible dimensions. In order for actual invariance of one characteristic to occur and therefore be recognized by the child, the changes in other dimensions must compensate for one another, leaving the primary dimension unchanged. The invariant quality is thus independent of the rearrangement of other dimensions (Lovell & Ogilvie, 1960). In the conservation of number, the number of objects in the stimulus configuration remains the same regardless of the spatial arrangement of the objects if no objects are added or taken away during configural transformations. The achievement of the process of conservation is considered by Piaget (1952b) to be "a necessary condition for all rational activity" (p. 3). The present study used the basic conservation of number task as a behavioral index of cognitive development. The task begins by showing the child two

parallel rows of objects equal in number, length, and density. The objects are placed in one-to-one correspondence. The child then is asked if both rows contain the same number of objects. When the child is satisfied that the rows are numerically equivalent, he or she watches as the experimenter spatially transforms one of the rows by moving the objects closer together (shortening the row and increasing the density) or spreading the objects apart (lengthening the row and decreasing its density). Regardless of the type of transformation, contraction or expansion, one of the rows is perceptually longer and less dense than the other, while the number of objects in each row remains unchanged. The child is asked to judge whether the rows contain the same number of objects and, if not, which row has more. Finally, the child is asked to explain what led him or her to make the initial judgment.

A number of validation studies have confirmed the general progression of cognitive development reported by Piaget (e.g., Braine, 1959; Lovell, Mitchell, & Everett, 1962; Lovell & Ogilvie, 1960; and Uzgiris, 1964). Other studies have verified Piaget's description of the developmental progression of the concept of number (Elkind, 1964; Pufall, Shaw, & Syrdal-Lasky, 1973; Wohlwill, 1960). Piaget describes three stages in the development of the conservation of number. In the first stage, known as the stage of nonconservation or global comparison, the child bases his judgment of the equality or inequality of the two rows on only one of the two global perceptual qualities inherent in the array, length of the row or density of the elements, with no attempt to coordinate these two dimensions. Further, the child at this stage makes little or no effort to establish one-to-one

correspondence between the elements of the rows. In the second stage, called the transitional or intuitive stage, the child spontaneously but somewhat diffidently establishes numerical correspondence between the elements of the two sets in response to questions about their initial equality. According to Piaget (1952b),

The child certainly considers the relationships of length and density simultaneously, since he can produce a copy equal in length and density to the model, but the coordination does not go beyond the plane of perception; i.e., as soon as the perceived figure, which made the correspondence possible, is altered, not only does the correspondence vanish, but also the coordination between length and density. (p. 81)

For Piaget, when intuitive preoperational coordination of length and density yields an accurate judgment of conservation but that irreversible coordination cannot support the judgment with a logical explanation, the child's response is also classified as intuitive conservation. Finally, in the stage of operational conservation (simply called "conservation"), the child bases his or her evaluation of equivalence of number on the reversible coordination of length and density and the resulting invariant numerical correspondence between elements; perceptual changes become irrelevant to numerical correspondence. With the achievement of operational conservation, the child can support his accurate judgment of invariance with a logical, coordinated explanation.

Criteria for judging the presence of conservation. As the meaning of conservation as a concept of cognitive development is considered, it is important to note that investigators have expressed differences in determining the criteria defining an adequate conserving response. A number of investigators have defined an adequate conserving response as requiring both an accurate judgment and an explanation of the conserving judgment (e.g., Gelman, 1969; Goodnow, 1973; Hamel & Riksen,

1973; Miller, 1973; Miller & Heldmeyer, 1975; Smedslund, 1961; Uzgiris, 1964; Wallach, Wall, & Anderson, 1967). Other researchers of conservation (Bruner, Olver, & Greenfield, 1966; Elkind, 1967) have asserted the adequacy of the conserving judgments ("same," "more," or "less") without logical verbal explanations. As an example, Elkind (1967) stated that what Piaget appears to say is not what he means to say. Elkind asserted that explanations are not necessarily a criterion for conservation as believed by many of his North American colleagues. He explained, "The ... types of verbal explanations ... are really post hoc rationalizations rather than veridical reflections of the processes leading to conservation" (Elkind, 1967, p. 20). Earlier (Elkind, 1964), he asserted that "Piaget used children's predictions, judgments, and explanations interchangeably as signs of conservation or non-conservation" (p. 21). Calhoun (1971) omitted the verbal response altogether and judged conservation of number by observing which row of candy objects was eaten by his young subjects because the row was perceived as having more candy. The controversy in effect focuses on the operational definition of conservation within individual studies. And in view of basic differences regarding which cognitive schemas immediately precede the full development of conservation (e.g., Bruner et al., 1966 versus Elkind, 1967), a final consensus is not likely soon. Recognition of the invariance of the essential quality of an event in spite of other changes, the heart of the conservation concept, does not seem to be in question. Rather the observable behaviors which demonstrate the certitude of the child's judgment of invariance are specified differently by different researchers. While precision in understanding the progression of children's thinking is important

and work should focus on determining valid and reliable behavioral predictors of the child's confident understanding of the invariance judgment that is conservation, the present study did not address that issue specifically. Based on a belief that the risk of assuming understanding which it is not mature is greater than the risk of asking for further demonstration of maturity, the present study used a moderate definition of conservation by requiring an adequate explanation of the conservation judgment in defining a conserving response.

Criteria for judging the level of initial cognitive development.

Many studies of conservation among younger children select only non-conservers as candidates for training methods. It is much simpler to operationally define a nonconserver as one who does not conserve on a conservation task. However, the present study, hoping to understand the development of conservation as a process which is more continuous than dichotomous, attempted to distinguish both nonconservers and intuitive conservers as described by Piaget (1952a) within the larger group of children who have not acquired the conservation of number response. As noted in an earlier paragraph, in addition to their inability to conserve number in the face of salient perceptual changes, nonconservers have been described by Piaget (1952a) as being unable to consistently establish one-to-one correspondence between the elements of two sets of objects. Nonconservers attend primarily to the perceptual configuration rather than number. Even when asked to construct a configuration containing the same number of objects as are present in a model configuration, nonconservers reportedly reconstruct the configuration with little regard for number, attending instead to shape, length, or other perceptual cues. Intuitive conservers, on the other

hand, whose representational thought is a step closer to logical thinking, have clearly acquired the rudiments of cardinal number and can establish quickly the one-to-one correspondence between stimulus groups or arrays. However, when a major perceptual change occurs in the configuration of one of the two rows without altering the number of elements, the intuitive conserver cannot recognize the invariance of number. The perceptual change is too compelling and overwhelms the tenuous cognitive recognition of number invariance. Previous observation has suggested however, that intuitive conservers do demonstrate more resistance to irrelevant perceptual change than nonconservers. Consequently, in the present study, children were classified as non-conservers or intuitive conservers according to three criteria:

(1) performance on the screening tasks for construction of equivalent sets; (2) judgments of conservation; and (3) explanations of conservation.

Components of conservation. Since research has verified the developmental progression of the concept of number according to Piagetian theory, second-order questions concerning the mechanisms of development have become appropriate foci of study. One such question concerns the experiences or component tasks from which the operation of conservation of number is ultimately constructed. One method of answering that question is longitudinal research which provides or withholds experiences considered to be crucial for the development of conservation and evaluates the appearance and adequacy of skills of conservation. To date few, if any, such long term studies controlling deprivation of or stimulation through crucial experiences have been performed. Another, more economical method which has been popular

among researchers assessing the processes and experiences relevant to cognitive development is specific training in or experience with suspected component skills. The basic paradigm involves a pretest to determine the child's current level of functioning, a subsequent training period or experience intended to facilitate relevant learning, and finally a posttest to assess the changes, if any, effected by the special experiences. Brainerd and Allen (1971), reviewing research on the induction of conservation through specific training, noted that seven of nine reviewed studies reported success in inducing conservation of number in children. The seven used a variety of training procedures, including discrimination of relevant cues (e.g., Gelman, 1969), verbal rule instruction (e.g., Beilin, 1965), or a mixture of both (e.g., Wallach, Wall, & Anderson, 1967). Incidentally, their more recent summary of the research on induction of conservation contrasted with Flavell's (1963) review which found little or no support for the induction of conservation through directed training.

Several recent studies have investigated the influence of perceptual cues on the conservation of number. Results of investigations by Gelman (1969) and by Wallach, Wall, and Anderson (1967) have demonstrated the Piagetian notion that perceptual cues, which are powerful during the sensorimotor and the preoperational periods, actually interfere with the recognition of conservation or invariance by distracting attention from relevant to irrelevant dimensions of a stimulus. Gelman (1969) employed a discrimination learning paradigm of oddity training in order to teach her child subjects to attend to a relevant stimulus dimension and to ignore irrelevant perceptual dimensions. Her results supported two conclusions concerning the

influence of perceptual factors on the acquisition of conservation of number. First, irrelevant, nonquantitative cues, such as length and density, are salient for young children; they are therefore more likely to attend to these perceptual cues than to quantitative dimensions. Second, a larger proportion of errors on those trials where irrelevant cues opposed relevant cues reflects significant interference by irrelevant dimensions in the evaluation of conservation. Wallach, Wall, and Anderson (1967), employing a reversibility training procedure among others, concluded that their reversibility training may have been successful in inducing conservation of number primarily because it taught the children to stop using misleading perceptual cues. According to these researchers,

Conservation probably never occurs when a situation provides what the subject takes to be a clear perceptual cue for nonconservation making the Ss stop using such a cue although it is still present may have been -- with or without the experience of reversibility training per se -- a crucial factor in the success of our doll-reversibility training procedure. (p. 441)

Research by Peters (1970) and by Whiteman and Peisach (1970) has provided a somewhat different perspective on the influence of perceptual cues on conservation without contradicting the conclusions cited above concerning the disruptive influence of length and density. The results of these two more recent studies suggested that the salience of perception may be manipulated to improve judgments of conservation of number. Whiteman and Peisach (1970), avoiding the often limited transfer or generalization of training effects, investigated the results of supporting a basic conservation of number task with increasing degrees of perceptual and sensorimotor support. The six conservation of number trials were presented in the following invariant

sequence providing a gradual increase in the number of supports:

(a) the standard conservation task with no supporting perceptual or sensorimotor cues; (b) a color cue, consisting of two identical sets of candies with five colors appearing in each row and with each color in one row aligned opposite its identical color in the second row; (c) the color cues as above plus sensorimotor experience using one hand to move the candies from the elongated position to the original position and back to the elongated configuration; (d) color cues plus guide lines connecting the colored candies in the elongated row with their twins in the unaltered row; (e) color cues, guide lines, and the one-handed reversibility experience; and (f) color cues, guide lines, and sensorimotor experience using both hands to move the candies from the elongated configuration to the original position directly opposite the unaltered row and back to the elongated position. As predicted, for conservation of number the accumulation of supporting cues resulted in gradually increasing proportions of conservation among both 5- and 6-year-old and 8- and 9-year-old subjects. Evidence also supported the authors' hypothesis that younger children would benefit more from sensorimotor experience while the older children would benefit from increasing perceptual support consistent with the postulated schemas in effect for each age group. Although the evidence deserved to be taken seriously, the conclusions of the study were marred by at least two weaknesses. First, the invariant sequence of presentation failed to control for learning or practice effects. The final trial, providing the greatest perceptual and sensorimotor support, had the added benefit of practice on five previous trials. Second, the older children, ages 8 and 9, whose performances showed the greatest

consistency, were beyond the age at which Piagetian theory predicts conservation will first occur despite distracting irrelevant cues. Piaget, supported by naturalistic observation as well as controlled experimentation, reports that reversible operational thought supports conservation of number regardless of the presence of irrelevant perceptual cues by the age of 7 or 8 years. Consequently, although the critical variable is performance on the conservation trials rather than age per se, the age of the older children confounds the interpretation of their performances. Nevertheless, the results of Whiteman and Peisach (1970) did suggest that certain perceptual cues may facilitate rather than interfere with conservation.

Using a training procedure, Peters' (1970) study included a treatment group which participated in discovery of conservation of number guided by perceptual cues. He used visual cues to assist the children in making the conservation judgment. The first three training trials used correspondence-accentuated materials. The materials consisted of two identical nine block subsets in which each block of the two sets (one for S and one for E) had a distinctive color. Peters expected the color-matching cues to facilitate the establishment of initial correspondence and to maintain the relationship between the sets throughout the transformations. The second three training trials in the perceptual-cue guided discovery used number-accentuated blocks. The blocks in these trials were white with sequins ordered one through nine in domino fashion on the upper surface. The dots were assumed to evoke counting and additionally could establish matching across sets. Results indicated that for all training groups the immediate posttest means were significantly higher than the control

group mean. On the immediate posttest, the means for the non-cued discovery group (NCD) and for the perceptual-cue-guided discovery (CG) group did not differ significantly, but a verbal didactic instruction (VDI) procedure produced a mean which was significantly higher than both of the first two training groups. However, "over the interim from post (sic) to delay posttest, the performance of perceptual cue discovery group improved, of the NCD group decreased, and of the VDI treatment group remained stable" (Peters, 1970, p. 713).

Both Whiteman and Peisach (1970) and Peters (1970) employed matched colors as a perceptual cue to induce correspondence between the two rows of stimuli. The correspondence established by the matching colors was intended to continue throughout transformations. However, the correspondence of matched colors is not purely a perceptual correspondence. The matched colors may well evoke iteration or counting of the objects using individual color symbols rather than arabic or roman numeral symbols. Such iteration still is primarily a cognitive rather than a perceptual task. Further both studies mixed perceptual cues, pure or not, with cognitive cues. White and Peisach (1970) included sensorimotor experience among their facilitating experiences. Sensorimotor experience is clearly defined by Piaget as a cognitive experience. Peters (1970) used number-accentuated blocks with distinctive arrays of sequins which could have evoked counting behavior quite readily. Thus neither study provided clear evidence of the support or interference of perceptual cues only.

The design used in the present study included a figurative (perceptual) cue conservation-like experience which more nearly approximates a perceptual task refined to reduce cognitive actions

or operations. The low operative cues-high figurative cues experience used an array consisting of all-yellow blocks placed on a dark blue background for high figure-ground contrast. It is significant to note that even in early childhood, perceptual tasks, except perhaps in cases of tachistoscopic presentation, cannot be entirely free of intellectual influence. Given Piaget's theoretical conviction that all perceptual behavior has its origin in sensorimotor actions, it is not possible to eliminate or control for the contribution of earlier visual or tactile-kinesthetic sensorimotor schemas. At best, one must assume that random sampling will control for any systematic differences in sensorimotor-guided perceptual experience.

Two studies have reported significant success in the induction of conservation of number using specific verbal rule instruction conditions (Beilin, 1965; Peters, 1970). Both of these investigators have worded their verbal instructions to provide three rules which explain the invariance of the number of objects in the face of configurational transformation. Peters' (1970) instructions will illustrate. Immediately following completion of each transformation-and-questioning sequence during training trials the following statement was made:

I have only moved the blocks. They are in another place, but there are just as many as before [equivalence rule]. See, I can put the whole bunch back the way they were [reversibility rule]. There are still the same number as before [equivalence] because I did not put in any more blocks, I only moved them [addition-subtraction rule]. (p. 713)

The only significant difference in the procedures employed by Beilin (1965) and Peters (1970) concerned the timing and therefore the frequency of the rules. Beilin explained conservation only when the child's response during training was incorrect. Peters included the

explanation on every trial regardless of success. Results in both studies showed that the children receiving the verbal rule instruction produced significantly more conservation responses than children in the control group. It is interesting to note that Hamel and Riksen (1973), using verbal rule instruction to induce conservation of liquid, segregated the explanations into two sets of rules based on identity and reversibility rather than combining them in one elaborate rule. The subjects receiving instruction for each of the rules performed significantly better than subjects in a control group. There was no significant difference between the two verbal rule instruction groups.

In the present study, the low figurative cues-high operative cues experience group participated in a procedure which included both sensorimotor experience and verbal rule instruction. The verbal rule instruction consisted of the equivalence rule, the reversibility rule, and the addition-subtraction rule. In order to provide operative sensorimotor experience, the child was asked to manipulate the objects in one of the two rows by establishing initial equivalence, by transforming the variable row, and finally by returning the transformed row to its original configuration.

Finally, the procedure for the control group experience was intended to minimize both perceptual (figurative) and cognitive (operative) cues as much as possible in order to evaluate the effects of high operative cues procedure and the high figurative cues procedure more effectively.

Hypotheses

In considering a developmental theory of cognition, one cannot

ignore the impact of past experience on the achieved level of comprehension and on the readiness to benefit from particular training. In the present study two levels of cognitive development were represented in the planned experiences -- nonconservers and transitional or intuitive conservers. Even within these two substages, individual differences in relevant experiences could not be controlled directly. Nonconservers and intuitive conservers were assigned randomly to the three experience groups; and the assumption was made that the events which contributed to the development of perceptual schemes and the actions which provided increments for intellectual schemes were not significantly different for the children within the groups prior to their planned experience.

The intention of this study was to intensify figurative experience or operative experience in separate groups and to observe the effects on the children's performance of the concrete operational task of conservation. Several hypotheses were tested. First, since the more mature late representational schemas of the intuitive conservers should assimilate the training more easily than the earlier representational schemas of nonconservers, the immediate and delayed posttest scores of intuitive conservers on the conservation of number task should be higher than those scores of nonconservers. Scores for conservation of length and of liquid should likewise be higher for the intuitive conservers. Second, because perceptual cues have been viewed as irrelevant and distracting in conservation tasks, the immediate and delayed conservation of number scores of children in the control group should be higher than the scores of children in the high figurative cues group. In other words, if past empirical and theoretical evidence

were accurate and the present study was derived accurately, the high figurative cues group should demonstrate the lowest posttest scores; the control group higher posttest scores; and the high operative cues group the highest posttest scores. The intuitive conservers as a group should require fewer trials to reach criterion for acquisition of the concept of conservation than nonconservers. Finally, the high operative cues group should require fewer trials to acquire the concept of conservation than the control and the high figurative cues groups.

METHOD

The basic paradigm for the study is a recurrent design in research focused on aspects of Piaget's conservation tasks (Beilin, 1965; Belman, 1969; Gruen, 1965; Hamel & Riksen, 1973; Smedslund, 1961; Wallach, Wall & Anderson, 1967). The basic paradigm includes a pretest of conservation ability, a training procedure designed to facilitate the learning of an important skill in judging conservation, and a posttest of conservation judgments. The present study elaborated the basic paradigm slightly by adding a screening procedure before pretesting in order to control for recently identified methodological problems (Beilin, 1965; Griffiths, Shantz & Sigel, 1967; Harasym, Boersma & Maguire, 1971) and by employing both immediate and delayed posttests of specific and nonspecific transfer. The steps in the resulting design occurred in the following order: (1) screening for basic concepts, (2) pretesting for conservation, (3) planned experience, (4) immediate posttesting, and (5) delayed posttesting (1 to 2 weeks). In the first session, the child was screened and pretested for conservation. In the second session, he or she was involved in a planned experience and in the immediate posttesting. The delayed posttesting was administered in the third session. For those children who required more than 16 experience trials to reach criterion performance in the planned experience, there was an additional training session of up to 16 trials before the immediate posttest.

Subjects

Sixty children from three public elementary schools and two private nursery schools participated in the study. The design called for a 3×2 nonparametric analysis of variance with an equal number of children in each of the six cells. Three separate planned experience groups -- Control, High Figurative Cues, and High Operative Cues -- made up one factor, and two levels of cognitive development -- nonconserver and intuitive conserver -- comprised the second factor. When the children had been assigned to one of the levels of cognitive development, based on criteria reported later in this section, they were randomly assigned to one of the planned experience groups. Assignment to the planned experience group was accomplished using a random number table. Although previous studies had demonstrated no sex differences for conservation judgments including conservation of number (Braine, 1959; Dodwell, 1962; Goldschmid, 1967; Pratoomraj & Johnson, 1966; Uzgis, 1964), approximately equal numbers of males and females were assigned to each experience group, as seen in Table 1. As a result 27 girls and 33 boys participated in the study. Further, 39 white children and 21 black children comprised the sample, a ratio of 1.85 white children to 1 black child. As seen in Table 1, approximations of this overall ratio were represented in each of the planned experience groups. The balance was not so consistent between intuitive conservers and nonconservers with respect to race or sex. Mean age for the sample was 68.6 months with a range of 45 to 88 months and a median of 68.5 months. Although a variety of socio-economic backgrounds was represented from children of university professors and professionals to children receiving welfare assistance, specific data

Table 1

Demographic Characteristics of the Sample by Level of Cognitive Development and by Planned Experience Group

	Age Range in Months	Mean Age	Sex		Race	
			M	F	B	W
Nonconservers	45-82	61.7	22	8	12	18
Intuitive Conservers	46-88	70.6	11	19	9	21
C ^b	46-88	71.4	11	9	6	14
HFC ^a	45-82	67.88	11	9	8	12
HOC ^b	46-80	66.33	11	9	7	13
Totals	45-88	68.6	33	27	21	39

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

on socio-economic level were insufficient to provide a specific distribution. The sample excluded children who were identified by teachers or by school records as having notable physical, perceptual, emotional, or intellectual difficulties and who were thus in need of special academic assistance.

Procedures and Materials

Screening. Prior to the administration of pre-experience conservation tests, each child was evaluated in order to assess his or her understanding of the relational terms "same" and "more" and his or her understanding of cardinal number. The assessment was intended to increase the cognitive homogeneity of the sample by setting a minimum standard for the children's understanding of the language which is critical for the conventional conservation procedure.

The significance of children's understanding of the relational terms has been investigated in two recent studies (Griffiths, Shantz, & Sigel, 1967; Harasym, Boersma, & Maguire, 1971). These two investigations reported dissimilar findings but share a common admonition. The results reported by Griffiths, Shantz, and Sigel (1967) suggested that 4- and 5-year-old children use the relational terms "same," "more," and "less" less accurately when judging conservation of number than when judging either conservation of weight or conservation of length. The term "same" which is the critical response for accurate judgment of conservation was used correctly significantly less often than were "more" and "less." In contrast to the accuracy of the term "more" reported by Griffiths, Shantz, and Sigel (1967), Harasym,

Boersma, and Maguire (1971) used the semantic differential to analyze the relational terms "more" and "less" and discovered that "less" was more stable in meaning during the development of conservation. Their results indicated that the meaning of "more" shifted with the development of conservation. Harasym, Boersma, and Maguire (1971) conclude that for children, the meaning of "more" becomes increasingly differentiated from the meaning of "less" with the development of conservation. Despite the conflict in their data, the conclusions of these two studies imply at least one common admonition: "To minimize confounding linguistic and conceptual abilities, the ability to judge similarity and to use the term 'same' correctly should be determined prior to testing for conservation" (Griffiths, Shantz, & Sigel, 1967, p. 486).

Because phrasing of the conservation question used in the present investigation included only the terms "same" and "more," these two terms were the focus of the first part of the assessment prior to pretesting for conservation. A two-part discrimination scheme was adapted from Miller (1973) to test the child's understanding of the terms "same" and "more." According to Harasym, Boersma, and Maguire (1971), "when the child is asked whether two objects 'are the same, or does one have more?' the full implication of the question is 'are they the same or different, and, if they are different, does one have more?'" (p. 786). Accepting the interpretation of Harasym et al. as possible, the child's understanding of the relational terms was assessed at two levels. First, the child's ability to discriminate the concepts of "same" and "different" was tested; immediately following, his or her understanding of "same" and "more" was assessed.

The procedure for assessing the child's understanding of "same" and "different" consisted of the presentation of two stimuli simultaneously. The stimuli were two-dimensional or three-dimensional geometric shapes. Both stimuli in each pair were alike or different on salient dimensions. Six displays were presented in counterbalanced order along an axis parallel to the subject. The basic question posed to the child was, "Are these things the same or are they different?" A detailed description of the stimulus materials and procedures used in the screening for understanding of "same" and "different" is presented in Appendix A. If the child completed the six arrays which constituted this first phase of the assessment of relational terms with no more than two errors, then the experimenter presented four additional arrays designed to assess his or her understanding of "same" and "more." The four arrays again consisted of familiar geometric shapes. The objects were arrayed in two groups with one or two objects per group, so that the total number of objects in any complete display ranged from two to four. Two arrays had equal numbers in each group; two had unequal numbers in each group. The groups were arranged on the right and left sides of the stimulus display board. The basic question for these four arrays was, "Do both sides have the same number of things or does one side have more things?" The details regarding the stimulus materials and the procedure for assessing each child's understanding of "same" and "more" are described in Appendix A.

In order to evaluate understanding of cardinal number, another potentially confounding basic concept, each child was asked to perform Beilin's (1965) number production task. The child was given a group of ten white discs and told, "Give me three of them, please." For the

second trial, he or she was asked, "Now, give me six of them." Finally, each child was asked, "Would you give me eight of them, please?" The discs were returned after each question so that the child began each trial with ten discs. The procedure was a non-feedback procedure; the child's responses were scored simply as correct or incorrect. Each child had to give an accurate response on two of the three number production trials in order to be selected for further participation in the study. The number production task was the last of the three procedures for assessing the presence of basic relational and number concepts as criteria for continued participation in the study.

The second phase of the screening procedure was intended to provide data for determination of the child's level of cognitive functioning. This phase consisted of the presentation of two number equivalence tasks. These tasks were also borrowed from Beilin (1965).

The first number equivalence task required the child to recognize the equivalence or non-equivalence of two sets of discs. Four trials were presented in counterbalanced order with two equivalent sets and two non-equivalent sets. One display of equivalent sets consisted of two arrays of four discs arranged in an equilateral triangular configuration with the fourth disc centered in one of the three sides. The location of the fourth disc was counterbalanced. The array nearest the child was located about six inches from him or her, and the second array was about two inches beyond the first. The other display of equivalent sets consisted of two arrays of three discs, also arranged in equilateral triangular form. These two arrays were located in the same positions described for the four-object arrays. The two non-

equivalent displays consisted of a three-item triangular display and a four-item triangular array as described above, counterbalanced for position nearer or more distant from the child and for the side in which the fourth disc was located. The four arrays are depicted in Appendix B. When the experimenter had constructed the array, he or she asked the child, "Do both groups have the same number of circles or does one group have more?" The responses were recorded. The child's responses to these four items were originally intended to serve as one criterion for classification of an individual as either a nonconservers or an intuitive conservers; however, the perfect or near-perfect performance of most children on this task rendered it rather meaningless in discriminating the two levels of cognitive development. The task was retained in spite of its shortcomings in order to ensure that all children would receive the same screening procedure. The second number equivalence task required the child to construct a set equivalent in number to a model constructed by the experimenter. He or she began these trials by positioning three discs in a 110-degree angle. He or she then told the child, "Here are some circles. Would you please build a group of circles so that your group has the same number of circles as my group?" The task was repeated with 5, 6, 7, and 8 circles in the angle. After the design containing three discs was built, the presentation of the other groups was randomized with the direction of the angle counterbalanced. (Appendix C depicts the arrangement of the five arrays.) Performance on this task was a primary determinant for classifying the children as nonconservers or intuitive conservers.

Pretests for conservation. Following the screening evaluation,

all children selected for continued participation in the investigation were tested for three types of conservation -- conservation of number, conservation of length, and conservation of liquid. The types of conservation pretests were presented in counterbalanced order. All items assessing a particular type of conservation were presented successively of course. With the child seated directly across the table from the experimenter, one stimulus array was designated as belonging to him or her and the other as belonging to the child for ease of identification. The child's stimulus, of course, was the one closest to the subject. The basic procedure for all three types of conservation was as follows: (1) The experimenter constructed the initial array with two configurations exactly alike. (2) The child was asked to confirm the equivalence of the initial configurations. (3) The experimenter then transformed one of the arrays so that the essential quality -- number, length, or amount of liquid -- was unchanged while perceptual dimensions varied. (4) The experimenter then posed the basic conservation question to the child, asking if the essential quality in both post-transformation configurations was the same or if the quality was changed so that one configuration had more (number, length, liquid). (5) Finally the experimenter asked the child to explain his or her response to the question, that is, to justify the conservation judgment of "same" or "more" ("longer" in the case of length). A detailed description of the stimulus materials and the instructions for each type of conservation pretest is presented in Appendix D.

Criteria for determining the initial level of cognitive development. By combining the child's performance on the construction of

numerical equivalence tasks with his or her performance on the conservation pretests, his or her level of cognitive development was determined. In the present study, a child was considered to be a nonconservor if his performance was characterized by the following: (1) not more than three correct responses on the screening procedure for construction of equivalent sets, (2) no correct judgments on the conservation of number pretests, and (3) no adequate or ambiguous explanations for conservation of number judgments. Intuitive conservers were designated on the basis of a performance that included: (1) at least four correct responses in the construction of equivalent sets (a performance clearly above chance), (2) no more than two correct judgments on the conservation of number items, and (3) no more than one adequate or ambiguous explanation for conserving judgments. The discrimination criterion for the construction of equivalence tasks was based on the following rationale. First, Gelman and Tucker (1975) demonstrated that even young nonconservers age 3, could accurately estimate numerosity of groups of 2 to 5 objects without an overt counting behavior. They labeled the child's perceptual recognition of the number of objects without counting as subitizing (p. 167). Based on their results, it seemed reasonable to assume that with the benefit of the subitizing response aided by chance, any child in the sample might have given three accurate responses without the ability to attend to number consistently and carefully. It seemed unlikely that the children would produce four or five correct responses if they did not attend to number readily, that is, if number was not a salient dimension given the appropriate instructions.

The quality of the child's conservation explanations was judged as

adequate if the child referred directly to former (i.e., pre-transformation) equality, reversibility of the transformation, compensation, addition or subtraction, or the irrelevance of the transformation for the quality of number. Inadequate explanations were magical, provided no information justifying the response, made reference only to visual perceptual cues, or contained only part of an adequate explanation. For example, if instead of saying, "You just moved them (the discs), and if you moved them back they would still be the same (or have the same number)," a child simply stated, "You just moved them," giving no further information, then the explanation was judged as inadequate. As noted in the description of the pretesting procedure, the child's judgment of invariance for each trial itself was recorded as correct (1) or incorrect (0). The child's explanation of number invariance followed the same binary scoring form. In summary, the profile for a nonconservor would be as follows: score for construction of equivalent sets -- 0 to 3; conservation of number score -- 0; and 0 adequate explanations of conservation. The profile for an intuitive conservor would resemble the following: score for construction of equivalent sets -- 4 or 5; conservation of number score -- 0 to 2; and no more than one adequate or ambiguous explanation of conservation.

Posttesting for conservation. The procedure and scoring criteria for posttests of conservation were exactly the same as for the pretests. Each child was tested twice following the planned experience. The first posttest was administered immediately after completion of the planned experience items during the second session. The second posttest was administered not less than one week or more than two weeks after the first posttest.

Planned experience in conservation of number. The primary apparatus for the planned experience groups included two painted hard-board rectangles, 56 cm by 46 cm, and twenty-eight 2.5 cm cubes. One of the boards had a non-glossy dark blue color; the other was painted a flat gray color. Fourteen of the cubes matched the flat gray color of the rectangle with which they were used, while the remaining fourteen cubes were painted with a glossy, bright yellow enamel and used with the dark blue display board. External reinforcement consisted of paper stars affixed either to the child's hand or arm or to a strip of colored paper.

The procedure for the Control Group, with low figurative cues and low operative cues, centered on the low contrast apparatus, that is, the gray display board and matching gray cubes. The conventional conservation task was modified in several ways for this experience. First, the practice of satisfying or convincing the child of the initial equivalence of the two rows was omitted. Instead the experimenter constructed two rows of cubes approximately three inches apart and parallel to each other and to the edge of the display board nearer the subject. After a brief pause, he or she transformed one of the rows according to the procedures outlined in the following paragraph and listed in Table 2. As with the pretests, the position of the row to be transformed (the experimenter's or the child's row) and the type of transformation (expansion or contraction) were counterbalanced as indicated in Table 2. The experimenter asked the conservation of number question. If the child's response was correct, the experimenter reinforced the response by repeating the child's response and presenting a star. If the child's response was incorrect, the experimenter

Table 2
Items Used in Planned Experience Groups for
Conservation of Number

Item	Number in Each Row in a Starting Position ^a	Transformation
1	$A = B$	A elongated
2	$A = B$	B elongated
3	$A > B$	B elongated
4	$A < B$	A elongated
5	$A = B$	A shortened
6	$A = B$	B shortened
7	$A > B$	A shortened
8	$A < B$	B shortened

^aEqual rows had seven blocks in each row. Unequal rows had seven blocks in the greater row and six blocks in the lesser row.

said, "That's not quite right; you have not discovered the secret about what happens to the blocks in our game."

In order to prevent response stereotypy, half of the eight distinct trials displayed an equal number of cubes in each row and the remaining four trials used two rows with unequal numbers of blocks (one row had one more cube than the other row). The trials using unequal rows required conservation of inequality. For the trials using equal rows, the initial, pre-transformation length and density of the two rows was equal, so that the cubes in one row were positioned directly opposite from the cubes of the second row. For the trials using the unequal rows, the pre-transformation rows were constructed with unequal lengths and densities. None of the cubes in the longer, more numerous row was directly opposite from a cube in the shorter, less numerous row. The items are presented descriptively in Table 2. These were not the only transformations possible; but in each transformation, there was a planned inconsistency between the length of the row and the number of cubes in the row so that the less numerous row was the longer row after transformation. Thus, the child had to make a conserving response in order to answer correctly (Gruen, 1965).

The procedure for the experience group with low operative cues and high figurative cues was the same procedure used for the Control group except for stimulus materials. Instead of dealing with low contrast matching gray displays, the High Figurative Cues experience group used the high contrast display with a dark blue display board and glossy bright yellow cubes.

The planned experience proceeded somewhat differently with low figurative cues and high operative cues. The figurative cues were minimized, as they were in the control group, by using the low contrast gray materials. The operative cues, which were accentuated, consisted of sensorimotor actions and verbal rule instruction. The planned experience involved the child's sensorimotor schemes by requiring him or her to participate in the actual construction and transformation of the rows. The intellectual operations which Piaget asserts are necessary for true conservation were emphasized in the form of a verbal rule centering on the invariance of the number of objects despite deformation of the length and density of a row.

Borrowing a procedure from Wallach, Wall, and Anderson (1967), the High Operative Cues experience proceeded in the following sequence: (1) Using the scheme described in Table 2, the child built his or her own row of blocks as the experimenter built his or her own. (2) The child was asked to confirm the equality or inequality of these two original rows. (3) Then the child transformed one of the rows by moving the blocks apart or closer together. (4) Finally each child was asked to make a conservation judgment and support the judgment with a reason. If both the conservation judgment and the explanation were accurate, the experimenter reinforced the child's response by giving him or her a gummed paper star and by repeating the response. If either the judgment or the explanation were inaccurate or ambiguous, then the experimenter's feedback to the child consisted of verbal rule instruction which included the notions of equivalence, reversibility, and no addition or subtraction of objects as logical reasons for the

invariance of number. Finally, the child was asked to return the transformed row to its original configuration. Greater details of the procedure for the High Operative Cues experience are provided in Appendix E. The verbal rule instruction provided experience in concrete operational reasoning. Having the child shift the cubes back into the original array provided sensorimotor experience with the principle of reversibility which Piaget asserts is essential for true conservation.

For all three planned experiences -- Control, High Figurative Cues, and High Operative Cues -- the criterion for learning to conserve number was correct responses on six consecutive trials. The maximum number of trials was 32. Early pilot experience with the children demonstrated frequent inability to attend carefully for 32 consecutive trials. Consequently, for the children in the present study, the planned experience was divided into two 16-trial sessions if the child did not reach criterion performance within the first 16 trials.

Controls for experimenter bias. For the first 22 children, three experimenters, two undergraduate psychology students working for course credit and the investigator, administered the three phases of the study -- screening and pretesting for conservation, planned experience, and posttesting. Unfortunately, when clearance was finally obtained to begin screening for the remaining 38 children, the University quarter was well under way and student volunteers were scarce. Consequently, for the final 38 children, one experimenter screened the children and assigned them randomly to planned experience groups. The second experimenter conducted the planned experience approximately one week later. Finally, with no indication of the experience in which a child

had participated, the first experimenter conducted immediate and delayed posttesting.

Judgment of the adequacy of responses. As noted in the introduction, the definition of a conserving response in the present study included an adequate explanation for the child's conserving judgment. Three judges, including the investigator, classified the children's explanations of conservation as adequate (1) or inadequate (0). The two judges, having limited familiarity with conservation tasks and conserving judgments and explanations, were trained to recognize acceptable conserving explanations. Criterion for adequate comprehension of the distinction between adequate and inadequate responses by the judges prior to classification of the children's responses was nine correct classifications out of ten statements which were taken from pilot study responses.

Of the 1,440 total explanations (60 children x 4 trials x 6 post-test conservation tasks), 87.5% were repetitious. In fact there were 83 unique explanations for conservation of number (out of 480), 50 unique explanations of conservation of length, and 46 unique explanations of conservation of liquid. Judges were only asked to classify the 179 unique conservation explanations offered by the 60 subjects.

RESULTS

Interjudge Agreement in Classifying Subjects' Responses

Interjudge agreement on classification of the subjects' responses on the posttests was reflected in two ways -- percentage of unanimous agreement and a Cochran Q test. Judges were asked to classify the unique responses to the three types of conservation tasks as conserving or nonconserving (ambiguous responses were considered as nonconserving). For conservation of number, the major dependent variable, the three judges achieved 97.5 per cent unanimous agreement in classifying the children's responses for 83 unique explanations. The judges achieved 95.7 per cent agreement in classifying the responses for conservation of liquid with 46 unique statements and 100 per cent agreement in classifying responses for conservation of length for 50 unique explanations.

In order to provide some comparison of the judges' classifications, the Cochran Q test was used to determine if the frequencies of the different classifications, conserving or nonconserving, differed among the three samples. Results of the test which is distributed like the chi-square statistic were not significant ($Q = 1.0005$; $df = 2$). It should be noted that the Cochran test does not assess correspondence among judges' classifications for individual statements but only a global comparison of frequencies of each classification for each judge.

Analysis of Dependent Variables

Rationale for nonparametric analysis. Standard analysis of variance techniques could not be applied to the data because responses were not normally distributed; specifically, the ranges for posttest scores of conservation were too compact. This condition was true for consideration responses which were defined by both accurate judgments with accurate explanations and those which were defined by accurate judgments alone. Table 3 presents the means and standard deviations for the immediate and delayed posttest conservation scores using judgments with explanations and illustrates the failure of the data to approximate a normal distribution. Table 4 depicts the means and standard deviations for the posttest conservation scores using judgments only; these data also fail to approximate a normal distribution. The distribution of trials to acquisition of the concept was highly skewed, thereby eliminating the standard analysis of variance technique. Table 5 presents the means and standard deviations for the number of trials to acquisition. Noting that the maximum number of trials was 32, the skewness is apparent. Therefore, a multivariate extension of the Friedman test was used. The Friedman nonparametric analysis of variance makes no assumptions about the frequency distribution of scores. It performs an analysis of the frequency distributions of the ranks of measurements rather than the measurements themselves. This test statistic is a chi-square statistic rather than an F statistic. It permits comparisons of main effects but no interactions. No interactions were predicted by the hypothesis. The analysis was conducted in two stages. First a six-variate analysis using the six posttest scores (immediate and delayed posttest scores for number, liquid, and length) was performed

Table 3

Means (M) and Standard Deviations (SD) of the Number of
Correct Judgment and Explanation
Conservation Responses

Immediate Posttest		Nonconserver			Intuitive Conserver		
		HFC ^a	C ^b	HOC ^c	HFC	C	HOC
Number	M	0.6	1.6	3.0	1.2	2.0	3.5
	SD	1.28	1.96	1.61	1.83	2.0	1.20
Length	M	0.0	0.4	0.8	0.6	0.0	1.9
	SD	0.0	1.2	1.6	1.28	0.0	1.81
Liquid	M	0.2	0.0	0.4	0.4	0.0	0.8
	SD	1.98	0.0	1.2	1.2	0.0	1.6
Delayed Posttest		HFC	C	HOC	HFC	C	HOC
Number	M	0.8	1.6	2.4	1.2	2.0	3.6
	SD	1.6	1.96	1.96	1.83	2.0	1.2
Length	M	0.2	0.4	0.8	0.8	0.0	1.6
	SD	0.6	1.2	1.33	1.6	0.0	1.96
Liquid	M	0.3	0.4	0.0	0.4	0.0	1.2
	SD	0.9	1.2	0.0	1.2	0.0	1.83

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 4

Means (M) and Standard Deviations (SD) of the Number of Correct Judgment Only Conservation Responses

Immediate Posttest		Nonconservers			Intuitive Conservers		
		HFC ^a	C ^b	HOC ^c	HFC	C	HOC
Number	M	0.7	1.6	3.3	1.2	2.0	3.5
	SD	1.27	1.96	1.27	1.83	2.0	1.2
Length	M	0.2	0.4	1.0	0.6	0.0	1.9
	SD	0.6	1.2	1.61	1.28	0.0	1.81
Liquid	M	0.9	0.3	0.5	0.5	0.2	0.9
	SD	1.3	0.9	1.2	1.2	0.6	1.58
Delayed Posttest		HFC	C	HOC	HFC	C	HOC
Number	M	0.9	1.6	2.8	1.2	2.0	3.6
	SD	0.3	1.96	1.83	1.83	2.0	1.2
Length	M	0.3	0.4	0.9	0.8	0.0	1.6
	SD	0.64	1.2	1.3	1.6	0.0	1.96
Liquid	M	0.4	0.6	0.1	0.4	0.4	1.2
	SD	0.92	1.28	0.3	1.2	1.2	1.83

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 5

Means (M) and Standard Deviations (SD) for Number
of Trials to Acquisition of
Conservation of Number

Nonconservers	Number of Trials	
	M	SD
HFC ^a	29.6	7.2
C ^b	27.1	9.39
HOC ^c	19.4	10.25
Intuitive Conservers	M	SD
HFC	27.0	8.08
C	24.4	9.87
HOC	14.3	9.30

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

for both conservation responses including judgment and explanation and for judgment-only conservation responses to determine the effects of the factors on the subjects' responses. The factors included the two levels of initial cognitive development -- nonconservers and intuitive conservers -- and the three experience groups -- Control, High Figurative Cues and High Operative Cues. In the second stage, the analysis was performed using trials to acquisition of the concept as the single variable.

Experience group effects. An inspection of the distributions of posttest scores for the experience groups in Tables 6, 8, 10, 12, 14 and 15 reveals the differences in the performances of subjects in each group. Holding the initial level of cognitive development constant as a block variable, the results of the overall tests of the experience group factor were significant for both judgment-with-explanation conservation scores and judgment-only conservation scores ($\chi^2 = 27.39$; $df = 12$; $p < .007$ and $\chi^2 = 32.95$; $df = 12$; $p < .001$ respectively). Once the global analysis determined that the overall effects of the three experience groups were significant in the degree to which they improved posttest performance, that is, in improving the scores in the respective distributions, more detailed analysis was reasonable. A separate global analysis for the effects of planned experiences on the distributions of posttest scores for each of the three types of conservation was performed. If this second analysis revealed significant effects, then performance of each experience group was compared with that of the other experience groups to discern the pattern of relationships among the distributions. In order to facilitate comparisons of the distributions of the posttest performances of the three experience

Table 6

Frequency Distributions of Raw Scores for the Conservation
of Number Posttests -- Judgment and Explanation

		Posttest Scores				
		0	1	2	3	4
Immediate Posttest						
Level of Cognitive Development						
Nonconservers	16	0	2	0	12	
Intuitive Conservers	12	0	0	1	16	
Planned Experience Groups						
C ^b	11	0	0	0	9	
HFC ^a	15	0	1	0	4	
HOC ^c	3	0	1	1	15	
Delayed Posttest						
Level of Cognitive Development						
Nonconservers	18	0	0	0	12	
Intuitive Conservers	13	0	0	0	17	
Planned Experience Groups						
C	11	0	0	0	9	
HFC	15	0	0	0	5	
HOC	5		0	0	15	

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

groups, the rank means for each posttest were compared pairwise by experience group using a z score. The original posttest scores were transformed into ranks for the nonparametric analysis of variance. Without further transformation, the rank means reflected the differences in the distributions, if any, among the different populations represented by each experience group. The z score provided a standardized comparison of each pair of experience groups -- Control and High Operative Cues, High Figurative Cues and High Operative Cues, and Control and High Figurative Cues. The significance of any differences between rank means was immediately evident from the cumulative normal probabilities of z scores.

Analysis of the effects of the experience groups on the posttest scores for conservation of number, the primary dependent variable, revealed significant differences in the distributions of the immediate posttest responses (judgment with explanation -- $\chi^2 = 15.37$; df = 2; $p < .0005$; and judgment only -- $\chi^2 = 16.5$; df = 2; $p < .0003$) and of the delayed posttest responses (judgment with explanation -- $\chi^2 = 10.087$; df = 2; $p < .007$; and judgment only -- $\chi^2 = 6.69$; df = 2; $p < .004$). Pairwise comparisons of the z scores (see Table 7) provided evidence that the scores for the High Operative Cues group in the distribution for judgment-with-explanation responses were significantly higher ($p < .01$) than the scores in the judgment-with-explanation distributions for the High Figurative Cues group or the Control group in the immediate posttest (see Table 6). These same pairwise comparisons for the distributions of judgment-with-explanation scores also indicated that the High Operative Cues group tended to score higher ($p < .001$) than the High Figurative Cues group on the delayed posttest of

Table 7
Comparison z Scores for Experience Groups
for Conservation of Number --
Judgment and Explanation

Immediate Posttest		
	C ^b	HFC
HFC ^a	1.6169	
HOC ^c	-2.2839*	-3.9008**
Delayed Posttest		
	C	HFC
HFC	1.2620	
HOC	-1.8930	-3.1550**

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

* $p < .01$

** $p < .001$

conservation of number. Pairwise comparisons of the z scores for the judgment-only conservation scores (see Table 9) demonstrated the same pattern for the distribution of immediate posttest judgment-only scores for conservation of number (see Table 8) as evidenced by the judgment-with-explanation scores. For the delayed posttest scores using the judgment-only criterion, the pairwise comparisons indicated that the High Operative Cues group tended to score higher ($p < .02$) than either the High Figurative Cues or the Control groups for conservation of number. There was no significant difference between the performances of the High Figurative Cues group and the Control group on either immediate or delayed posttests of conservation of number for judgment-with-explanation or judgment-only responses.

Similarly, analysis of the nonspecific transfer effects of the number experience groups on posttest scores for conservation of length demonstrated significant differences among the distributions of the groups on both the immediate posttests (judgment with explanation -- $\chi^2 = 9.682$; $df = 2$; $p < .008$; and judgment only -- $\chi^2 = 10.009$; $df = 2$; $p < .006$) and the delayed posttests (judgment with explanation -- $\chi^2 = 5.805$; $df = 2$; $p < .05$; and judgment only -- $\chi^2 = 6.694$; $df = 2$; $p < .035$). Again pairwise comparisons (see Table 11) provided data suggesting that the scores in the judgment-with-explanation distribution for the High Operative Cues group were significantly higher ($p < .003$) than those for the High Figurative Cues group and the Control group on the immediate posttest of length (see Table 10). On the delayed posttest for conservation of length, scores in the distribution of judgment-with-explanation responses for the High Operative Cues group tended to be higher than for the Control group

Table 8
Frequency Distributions of Raw Scores for the Conservation
of Number Posttests -- Judgment Only

	Posttest Scores				
	0	1	2	3	4
Immediate Posttest					
Level of Cognitive Development					
Nonconservers	14	1	2	1	12
Intuitive Conservers	13	0	0	1	16
Planned Experience Groups					
C ^b	11	0	0	0	9
HFC ^a	14	1	1	0	4
HOC ^c	2	0	1	2	15
Delayed Posttest					
Level of Cognitive Development					
Nonconservers	16	1	0	0	13
Intuitive Conservers	13	0	0	0	17
Planned Experience Groups					
C	11	0	0	0	9
HFC	14	1	0	0	5
HOC	4	0	0	0	16

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 9
Comparison z Scores for Experience Groups
for Conservation of Number --
Judgment Only

Immediate Posttest		
	C ^b	HFC
HFC ^a	1.5024	
HOC ^c	-2.5172**	-4.0195***
Delayed Posttest		
	C	HFC
HFC	1.0869	
HOC	-2.2049*	-3.2918***

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

* $p < .01$

** $p < .006$

*** $p < .0007$

Table 10

Frequency Distributions of Raw Scores for the Conservation
of Length Posttests -- Judgment and Explanation

		Posttest Scores				
		0	1	2	3	4
Immediate Posttest						
Level of Cognitive Development						
Nonconservers	27	0	0	0	0	3
Intuitive Conservers	22	1	2	0	0	4
Planned Experience Groups						
C ^b	19	0	0	0	0	1
HFC ^a	18	0	1	0	0	1
HOC ^c	12	1	1	0	0	5
Delayed Posttest						
Level of Cognitive Development						
Nonconservers	25	1	2	0	0	2
Intuitive Conservers	24	0	0	0	0	6
Planned Experience Groups						
C	19	0	0	0	0	1
HFC	17	1	0	0	0	2
HOC	13	0	2	0	0	5

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 11
Comparison z Scores for Experience Groups
for Conservation of Length --
Judgment and Explanation

Immediate Posttest		
	C ^b	HFC
HFC ^a	0.3945	
HOC ^c	-2.8702***	-2.4758**
Delayed Posttest		
	C	HFC
HFC	-0.7359	
HOC	-2.3548*	-1.6189

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

* p < .009

** p < .006

*** p < .003

($p < .009$). Pairwise comparisons of z scores for the judgment-only responses for conservation of length on the immediate posttest also demonstrated that the scores of the judgment-only distribution for the High Operative Cues group were significantly higher ($p < .01$) than for the High Figurative Cues group and the Control group (see Tables 12 and 13). And for the delayed posttest conservation of number responses using the judgment-only criterion, scores in the distribution of the High Operative Cues group tended to be higher than those of the Control group ($p < .005$). There was no significant difference between High Operative Cues and High Figurative Cues distributions for either judgment-with-explanation or judgment-only responses.

For conservation of liquid, analysis of the effects of the experience groups on the posttest performance yielded no significant difference for the distributions on the immediate posttest (judgment with explanation -- $\chi^2 = 3.006$; $df = 2$; and judgment only -- $\chi^2 = 2.885$; $df = 2$) or the delayed posttest (judgment with explanation -- $\chi^2 = 1.052$; $df = 2$; and judgment only -- $\chi^2 = 0.612$; $df = 2$). No further analysis was appropriate (see Tables 14 and 15).

The second stage of the nonparametric analysis of variance evaluated the effects of the experience groups on the number of trials required to acquire the concept of conservation. Global analysis indicated a significant difference among experience groups in the distributions for number of trials to criterion for acquisition ($\chi^2 = 14.117$; $df = 2$; $p < .0009$). Further analysis (see Tables 16 and 17) demonstrated that the scores in the distribution for number of trials for acquisition by children in the High Operative Cues group was significantly lower than the same distribution for children in the

Table 12

Frequency Distributions of Raw Scores for the Conservation
of Length Posttests -- Judgment Only

	Posttest Scores				
	0	1	2	3	4
Immediate Posttest					
Level of Cognitive Development					
Nonconservers	25	0	2	0	3
Intuitive Conservers	22	1	2	0	5
Planned Experience Groups					
C ^b	19	0	0	0	1
HFC ^a	17	0	2	0	1
HOC ^c	11	1	2	0	6
Delayed Posttest					
Level of Cognitive Development					
Nonconservers	23	2	3	0	2
Intuitive Conservers	24	0	0	0	6
Planned Experience Groups					
C	19	0	0	0	1
HFC	16	1	1	0	2
HOC	12	1	2	0	5

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 13
Comparison z Scores for Experience Groups
for Conservation of Length --
Judgment Only

Immediate Posttest		
	C ^b	HFC
HFC ^a	-0.6784	
HOC ^c	-3.0153***	-2.2269*
Delayed Posttest		
	C	HFC
HFC	-1.0016	
HOC	-2.5667**	-1.5650

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

* p < .01

** p < .005

*** p < .001

Table 14

Frequency Distributions of Raw Scores for the Conservation
of Liquid Posttests -- Judgment and Explanation

		Posttest Scores				
		0	1	2	3	4
Immediate Posttest						
Level of Cognitive Development						
Nonconservers	28	0	1	0	1	
Intuitive Conservers	27	0	0	0	0	3
Planned Experience Groups						
C ^b	20	0	0	0	0	0
HFC ^a	18	0	1	0	0	1
HOC ^c	16	1	0	0	0	3
Delayed Posttest						
Level of Cognitive Development						
Nonconservers	28	0	0	1	1	
Intuitive Conservers	26	0	0	0	0	4
Planned Experience Groups						
C	19	0	0	0	0	1
HFC	18	0	0	1	1	
HOC	17	0	0	0	0	3

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 15

Frequency Distributions of Raw Scores for the Conservation
of Liquid Posttests -- Judgment Only

	Posttest Scores				
	0	1	2	3	4
Immediate Posttest					
Level of Cognitive Development					
Nonconservers	23	2	2	1	2
Intuitive Conservers	24	2	1	0	3
Planned Experience Groups					
C ^b	18	1	0	1	0
HFC ^a	14	2	2	0	2
HOC ^c	15	2	0	0	3
Delayed Posttest					
Level of Cognitive Development					
Nonconservers	25	2	1	0	2
Intuitive Conservers	25	0	0	0	5
Planned Experience Groups					
C	17	0	1	0	2
HFC	17	1	0	0	2
HOC	16	1	0	0	3

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 16
Frequency Distribution of Raw Scores for Number
of Trials to Acquisition

	Number of Trials												
	6	8	10	11	12	13	14	17	18	22	30	31	32
Level of Cognitive Development													
Nonconservers	1	3		1	2	1	1				1	1	19
Intuitive Conservers	2	3	3	1	1	1		1	2	1			15
Planned Experience Groups													
C ^b	2		1	1					2		1		13
HFC ^a		1		1		1				1			16
HOC ^c	1	5	2		3	1	1	1				1	5

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

Table 17

Comparison z Scores for Experience Groups
for Number of Trials to Acquisition

	c ^b	HFC
HFC ^a	-1.0282	
HOC ^c	2.6155*	3.6437**

^aHFC - High Figurative Cues group

^bC - Control group

^cHOC - High Operative Cues group

* $p < .004$

** $p < .0001$

Control group or the High Figurative Cues group ($p < .004$). Once more, there was no significant difference between the High Figurative Cues group and the Control group.

Effects of initial level of cognitive development. Holding the effects of the three experience groups constant as a block variable, the overall test of the effect of the initial level of cognitive development was not significant (judgment with explanation -- $\chi^2 = 4.413$; $df = 6$; and judgment only -- $\chi^2 = 5.835$; $df = 6$). Likewise, comparison of the number of trials to acquisition revealed no significant differences in the distributions of nonconservers and intuitive conservers ($\chi^2 = 2.519$; $df = 1$).

Summary of hypothesis testing. Considering both the more demanding judgment-with-explanation criterion as well as the judgment-only criterion for conserving responses, there was no support for the first hypothesis which stated that intuitive conservers would score higher than nonconservers on all posttests. The second hypothesis, which predicted that children in the High Operative Cues group would score higher than the children in the Control group, who in turn would score higher than children in the High Figurative Cues group on the posttests, was partially supported. The data indicated that the scores in the distributions of both judgment-with-explanation and judgment-only posttest scores for the High Operative Cues group exceeded the scores in the distributions for both the High Figurative Cues group and the Control group on the immediate posttests for conservation of number. On the delayed posttest, using the judgment-with-explanation criterion, the scores in the distribution for the High Operative Cues group only exceeded the scores in the distribution of the High Figurative Cues

group. Using the judgment-only criterion, the scores in the distribution for the High Operative Cues group exceeded the scores in the distribution for both the High Figurative Cues group and the Control group. Evidence also indicated that for both judgment-with-explanation and judgment-only criteria situations, the scores in the distribution for the High Operative Cues group exceeded the scores in the distributions for both the High Figurative Cues group and the Control group on the immediate posttest of conservation of length and exceeded the scores in the distribution for the Control group on the delayed posttest of conservation of length. There was no evidence of a difference between the High Figurative Cues group and the Control group on any of the posttests.

Finally, data indicated that the High Operative Cues group acquired the concept of conservation of number in significantly fewer trials than either the High Figurative Cues group or the Control group. However, since there was no difference in the distributions of the number of trials to acquisition for nonconservers and intuitive conservers, the first part of the hypothesis was not supported.

DISCUSSION

In considering the results of the present study, note that initially, after the pretesting for conservation, the investigator assumed that the error of falsely classifying a response as conserving when a child had not acquired the concept of operational conservation was a more serious risk than the error of failing to recognize conserving responses which were in fact valid. In other words, to conclude falsely that a child had acquired the concept of conservation and thus ignore his or her need for the relevant experience was more serious than to mistakenly judge his responses as less mature, that is, nonconserving, and provide additional experience. This assumption led to the decision to use a more complete, more complex definition of a conserving response in order to verify the reasoning process used to make the conserving judgment. The assumption had the effect of decreasing the probability of a Type I error, that is, that the results would suggest the false conclusion that the experience in the various groups had resulted in significant cognitive progression. Simultaneously, the probability of a Type II error was increased since a simpler, less demanding standard of classification might have produced a more significant difference and the more probable and perhaps erroneous acceptance of the alternative hypothesis. Later, however, the less demanding criterion of a correct judgment only was adopted for the purpose of additional analysis and comparison.

Comparison of the effects of the three planned experience groups and of the two initial levels of cognitive development on the posttest conservation responses comprised of both accurate judgments and explanations with same effects on the judgment only conservation responses revealed just one noticeable difference. With the less stringent criterion, the distribution of the judgment only conservation responses was significantly higher for the High Operative Cues group than for both the High Figurative Cues and the Control groups on the delayed posttest for conservation of number. For the judgment and explanation conservation criterion, only the High Figurative Cues group was significantly different (lower) than the High Operative Cues group on the delayed posttest for conservation of number. These results are consistent with the argument formulated by Bruner et al. (1966) and Elkind (1967) that there is no essential difference between conservation judgments with or without adequate explanations. But this argument is based on the assumption that identity (not reversibility) is the basic characteristic of conservation. The fact that analyses based on judgment with explanation as well as judgment only yield compatible results therefore indirectly supports Piaget's belief that conservation is characterized not only by the identity operation but also by reversibility.

Although the mean numbers of conserving responses for the quality of number across experience groups were in the expected direction for both judgment-with-explanation and judgment-only criterion, the results were only partially significant. The more intense cognitive experience of the High Operative Cues group produced the expected result for conservation of number and conservation of length on the immediate

posttest. There was a significantly higher distribution of conserving responses for the High Operative Cues experience children than for the High Figurative Cues or Control children using both judgment-with-explanation and judgment-only conservation response criteria on the immediate posttest. On the delayed posttest, the scores in the distribution for conserving responses including judgment and explanation by children in the High Operative Cues group exceeded those scores for the High Figurative Cues group on conservation of number and those for the Control group on conservation of length. For the judgment-only conservation responses on the delayed posttests, the High Operative Cues group's distribution of scores was significantly higher than both High Figurative Cues and Control groups for conservation of number. Further, the results indicated that the children who participated in High Operative Cues experience achieved acquisition of the conservation concept significantly quicker than the children participating in the other two groups individually. Thus, the results were consistent with Beilin (1965) and Peters (1970) in affirming that verbal rule instruction as a model for adequate reasoning about conservation of number is an effective experience. There was limited transfer of learning to conservation of length and no transfer to conservation of liquid. The endurance of the conserving response for number over the 10 to 14 day delay before the second posttest suggested that the acquisition of the concept was not simply due to specific operant learning.

As a matter of intention in the present study, the effectiveness of more intense cognitive experience of the High Operative Cues group was of secondary importance. Of greater interest were the effects, if any, of manipulating certain perceptual cues in the children's

experiences of a conservation-like task. The specific manipulation involved essentially contrasting the intensity of perceptual cues in the Control and High Figurative Cues groups. There was no clear evidence in the results of any significant effects related to the manipulation of these perceptual cues. Comparison of the posttest performances of children in the High Figurative Cues group with performances of children in the Control group yielded no significant differences on any of the three types of conservation. Unfortunately, the present data provide no clues as to reasons for the absence of significant differences in the responses of children experiencing the high contrast materials. Numerous references to size and length among the children's explanations of their nonconserving responses suggest that length was a salient cue in the misjudgments in both High Figurative Cues and Control experiences. The only conclusion which seems warranted from the present data is that the attempt to diminish attention to the irrelevant transformation by using a matching stimulus array in the Control experience was unsuccessful and that subjects attended to the irrelevant transformations in the High Figurative Cues and Control experiences with equal intensity. Since the work of Gelman and Tucker (1975), Peters (1970), and Whiteman and Peisach (1970) has demonstrated that heterogeneous stimulus objects support better operative performance, reasoning inversely, it seems that homogeneous objects should provide less support for operative functioning. In fact, Gelman and Tucker (1975) have speculated that the different stimulus objects facilitate subjects' estimations of number by calling attention to individual objects. However, one bit of indirect evidence precludes a clear rejection of the notion that

the manipulation of perceptual cues had no effect. As noted previously, comparison of the effects of the planned experiences on the acquisition of conservation of number revealed that during immediate posttesting using the judgment-with-explanation conservation criterion, the children in the High Operative Cues group performed significantly better than the High Figurative Cues group and the Control group. However, after 10 to 14 days, there was no significant difference between the performance of children in the High Operative Cues group and children in the Control group, both of whom had experienced the low-contrast gray stimulus materials. In contrast, the significant differences between the distribution of the High Operative Cues scores for conservation of number and the High Figurative Cues group's distribution of scores for conservation of number was clearly maintained. The strength of the question raised by this result was not supported by the results for judgment-only responses for conservation of number or the results for judgment-with-explanation responses or judgment-only responses for conservation of length.

In view of the intention of the present study to contrast figurative (perceptual) cues in two planned experiences and to contrast basically figurative experiences with intense operative (cognitive) experiences, conclusions from the study of figurative and operative aspects of children's logical inference by Youniss and Dennison (1971) seem appropriate to consider. Based on the results of their study of transitive relations influenced by figurative cues, operative cues, or both, they concluded that figurative and operative aspects of knowing about the world appear to be complementary within developmental levels and that "the operative aspect, stemming from structural change,

appears to dominate the figurative" (p. 1846). The advantage of the complementary system as seen by Youniss and Dennison is "that it takes into account the specificity of the objects' properties as well as incorporating common properties into a structural system" (p. 1846). Perhaps the attempts by Whiteman and Peisach (1970) and by Peters (1970) to study combinations of cognitive and perceptual cues are more in keeping with actual human ways of knowing.

Finally, another important factor in the present study, the initial level of cognitive development, produced no significant effects for conserving responses in the posttesting for the three types of conservation or for the speed of acquisition of the concept of conservation. The results suggest three possible conclusions. First, the operational definition of the distinction between the two levels of cognitive development may be inadequate by itself and thus not sufficiently discriminating. Second, the experience groups may have affected children at each level in the same way. The latter alternative seems highly unlikely in view of the pattern of significant and nonsignificant results in the analysis of the effects of the experience groups. Third, Table 1 clearly indicates a significant imbalance by sex among children in the two levels of cognitive development. Although previous research, cited in the Method section, consistently indicates no sex differences in the ability to conserve, the influence of the children's gender cannot be ruled out in attempting to account for the lack of significance between the nonconservers and the intuitive conservers. Nevertheless, it appears that the present attempt to classify youngsters as intuitive conservers based primarily on their ability to establish one-to-one correspondence was insufficient to

define this level of cognitive development.

For those who share the author's concern for assessing and understanding the processes which children must experience to advance from global comparisons through a transitional level to operative (logical) conservation, several options are available. First, one might decide to discriminate nonconservers from intuitive conservers by widening the gap in the ability to establish one-to-one correspondence, that is, to define nonconservers as children who are unable to establish one-to-one correspondence at all and intuitive conservers as children to establish one-to-one correspondence four or five times out of five trials. The apparent difficulty with that decision would be finding children who were absolutely unable to establish one-to-one correspondence and yet were able to understand the basic concepts and relational terms. Second, one might follow the lead of Brainerd and Brainerd (1972) and Miller and Heldmeyer (1975) by defining intuitive conservation in terms of the ability to predict conservation prior to observing the transformation followed by the inability to maintain the conserving response after seeing the transformation. Third, one might select intuitive conservers as Harasym, Boersma, and Maguire (1971) did by classifying children who make conserving judgments but are unable to explain them adequately as intuitive conservers. The data from the present study indicate little or no difference between children who make conserving judgments consistently and those who make judgments with adequate explanations consistently. Finally, one might use a combination of the various descriptive behaviors which have been used singly to define intuitive or transitional conservation. It remains for some investigator to carefully assess the various definitions

of intuitive conservation to determine if researchers define the intuitive level too narrowly by using only a single criterion. Although the results of this present study do not directly support the results of Gelman (1969) and of Wallach, Wall, and Anderson (1967), they are nonetheless consistent with the conclusion reached in each of these studies that experience which focuses the child's attention on relevant stimulus dimensions in making the appropriate conservation judgment facilitates the acquisition of the concept of conservation.

In summary, the results suggest four major conclusions. First, consistent with previous findings, the children whose planned experience included intense cognitive cues, both sensorimotor actions and verbal rule instruction focusing attention on relevant attributes of the conservation of number task, demonstrated a significantly higher distribution of conserving responses on the immediate posttests for conservation of number and for conservation of length than children in two other experience groups which minimized cognitive (operative) cues. The children in the High Operative Cues experience for conservation of number also displayed higher distributions than children in the High Figurative Cues experience for delayed posttest scores on conservation of number. Likewise, the distribution of the delayed posttest scores for conservation of length was significantly higher for High Operative Cues children compared with the same posttest scores for the youngsters in the High Figurative Cues experience. The significant results for the conservation of length posttests imply generalization of the effects of the cognitive experience with number to another significant attributes of things in the world. Third, operational definition of the achievement of intuitive conservation

of number using the child's ability to construct one-to-one correspondence spontaneously does not appear to be adequate. Finally, there was no support for the expectation that with minimal cognitive structural cues in two kinds of brief experience (Control and High Figurative Cues) the experience with the most pronounced perceptual cues (High Figurative Cues) would interfere with acquisition of the concept of conservation to a greater degree.

APPENDIX A

MATERIALS AND PROCEDURES FOR SCREENING TO
ASSESS BASIC CONCEPTS

Screening for the Relational Terms "Same" and "Different"

The six arrays for determining the child's understanding of the relational terms "same" and "different" were presented as follows:

Two-dimensional objects:

- (1) Two green circles of equal size (5 cm in diameter)
- (2) A yellow triangle and a blue circle of approximately equal size (5 cm at the base and 5 cm in diameter respectively)

Three-dimensional objects:

- (3) Two yellow square blocks of equal size (3.8 cm square)
- (4) A blue triangular block and a yellow square block of approximately equal size (3.8 cm at the base and 3.8 cm square respectively)
- (5) A blue square block and a yellow square block of equal size (3.8 cm square)
- (6) A yellow square block and a yellow triangular block of approximately equal size (3.8 cm square and 3.8 cm at the base respectively)

Arrays 1 and 3 were expected to elicit a "same" response; arrays 2 and 4 were intended to elicit a "different" response; and arrays 5 and 6 were designed to elicit both responses. The discrimination tasks were introduced with these instructions, "I am going to show you some shapes and some blocks, two at a time. I want you to look at them very carefully. And then I will ask you to tell me if they are the same

or if they are different. Are you ready?" After each of the first four arrays was presented, the child was asked, "Are they the same or are they different?" The order of the relational terms in this question and in all similar questions in this study involving two different relational terms was counterbalanced. The response was recorded. The only reward was the experimenter's recognition of a correct response. For arrays 5 and 6, two sets of questions were asked. First, "Are they the same in any way? If so, how are they the same?" Then, "Are they different in any way? If so, how are they different?" Again responses were recorded. The reader may have noticed that the stimuli in arrays 1 through 4 used redundant relevant cues in order to elicit the basic concepts "same" and "different." The redundancy was intended to make the initial discrimination as easy as possible. It was hoped that by maximizing the cues relevant to a successful trial the situation could be rendered less threatening for the child. In arrays 5 and 6, however, the discrimination involved nonredundant cues which allowed the objects to be simultaneously alike on two dimensions and different on another. These last two arrays were included because the conservation of number task involves arrays that are alike in all dimensions before transformation; but as a result of the transformation, the two rows of objects differ in length and density while remaining similar in number of objects.

Screening for the Relational Terms "Same" and "More"

The four arrays designed to assess the child's understanding of "same" and "more" consisted of the following stimuli:

Two-dimensional objects:

- (7) Four yellow squares, presented in two pairs (5 cm square)

Three-dimensional objects:

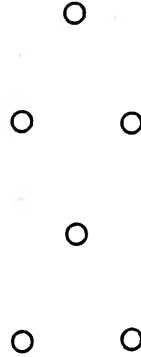
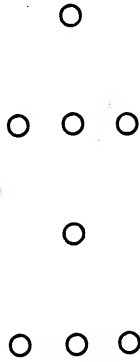
- (8) One blue block, a cube, and two smaller blue blocks whose combined thickness was equal to the single block (3.8 cm square and 3.8 x 1.9 cm x 3.8 cm)
- (9) Two red blocks separated into one-block sets (3.8 cm square)
- (10) One gray triangular block and two smaller gray triangular blocks whose thickness was equal to the base of the single triangular block (3.8 cm base and 1.9 cm bases respectively; all three triangles were 3.8 cm in height)

Displays 7 and 9 were expected to elicit a "same" response; displays 8 and 10 were designed to elicit a "more" response. These displays were presented in counterbalanced order using a procedure similar to the one described for the screening for the concepts "same" and "different." The stimuli were arranged on an axis parallel to the child with separate stimuli or stimulus pairs side by side. When the stimuli were arranged in front of him or her, the experimenter asked, "Do both of these groups have the same number or does one have more?" Once again, in order to minimize cues within the question which might suggest the experimenter's preference for a particular response, the order of the terms was counterbalanced. Responses were recorded. Criterion for continuation was three correct responses on the four trials in this group.

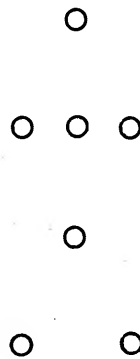
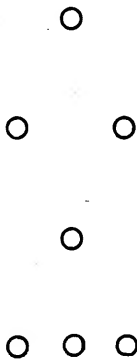
APPENDIX B

DISPLAYS FOR RECOGNITION OF NUMBER EQUIVALENCE

Equivalent Sets



Nonequivalent Sets

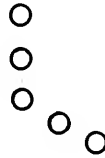


APPENDIX C

DISPLAYS FOR CONSTRUCTION OF NUMBER EQUIVALENCE



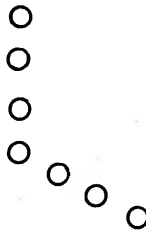
three discs



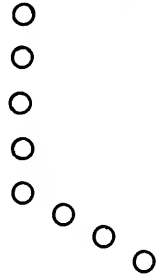
five discs



six discs



seven discs



eight discs

APPENDIX D

MATERIALS AND PROCEDURES FOR PRETESTS
OF CONSERVATION

Conservation of Number

The pretesting for conservation of number included four trials counterbalanced for position of the variable row (the row to be transformed), type of transformation (contraction or expansion), and order of the relational terms in the conservation question. The materials consisted of a hardboard stimulus display board, 56 cm x 46 cm, five white discs and five blue discs, each 3.8 cm in diameter. The procedural actions and instructions were as follows:

The experimenter introduced the tasks for conservation of number by saying, "We are going to play a game using this board and these white and these blue circles. First I am going to make two rows, one with white circles and one with blue circles. I am going to put the same number of circles in each row." The experimenter simultaneously constructed two equivalent rows which were parallel to the child's and to one another with five discs in each row. One row consisted of white discs positioned equidistantly. The rows were thus equal in number, length, and density. The experimenter then asked, "Tell me, do you think that your row has the same number of circles as my row?" If the child had any doubts about the initial equivalence of the two rows, the experimenter made minor adjustments in alignment in order to assure him or her that the rows were numerically equal. When the child was satisfied that the two rows were equal, the experimenter asked him or her to watch very carefully while the experimenter transformed one row either by spreading the objects apart until the extended row was about two inches longer than the standard (unchanged) row or by moving the objects closer together until the contracted row was about two inches shorter than the standard row. The transformed row maintained equal distances between its objects. The experimenter then

asked, "Does your row have the same number of circles as my row, or does one row have more circles?" The child's expressed judgment, "same number" or "more," was always followed by the inquiry, "What makes you know that?" or "How can you tell?" The trial terminated with the child's explanation. The board was cleared of discs, and a new trial begun with the experimenter saying, "I'm going to make two new rows, etc."

Conservation of Length

The pretesting for conservation of length consisted of four trials counterbalanced for position of the variable stick, the direction of the transformation (right or left), and the order of the relational terms in the conservation of length question. The materials included two square wooden sticks or rods, 20 cm x 1.3 cm x 1.3 cm, and a hard-board display board, 56 cm x 46 cm. The procedure for the pretest of conservation of length was as follows:

The experimenter introduced the tasks of conservation of length by saying, "We are going to play a game with this board and these yellow sticks. First, I will lay them down here so that mine is right across from yours." The experimenter positioned the sticks initially so that they were parallel to one another and to the edge of the board nearest the child. They were placed about two inches apart. They were located directly opposite one another so that an imaginary line perpendicular to and bisecting one stick would necessarily bisect the other as well. The experimenter then asked the child, "Tell me, do you think that those sticks are the same length?" If the child had any doubts about the equivalence of the lengths of the two sticks, the experimenter made minor adjustments in alignment in order to assure the child that the two sticks were of equal lengths. When the child was satisfied that the two sticks were equally long, the experimenter asked him or her to watch carefully as the experimenter moved one of the sticks either to the right or to the left about one and a half inches. The experimenter then asked the conservation of length question, "Is this stick the same length as that stick, or is one stick longer?" When the child had responded with a judgment of "same" or "longer," the experimenter followed with, "What makes you know that?" The trial terminated with the child's explanation.

Conservation of Liquid

The pretesting for conservation of liquid included four trials counterbalanced for which of two identical containers of liquid was transformed, the type of transformation (pouring into a tall, narrow container or into a short, wide container), and the order of the relational terms in the conservation of liquid question. The materials consisted of four containers. Two were identical bowls, 2.1 cm deep and approximately 7 cm in diameter. One was a taller, narrow container, 8.1 cm deep and 4.8 cm in diameter. The fourth was a wide, short container, 1.3 cm deep and 13.9 cm in diameter. The following procedure was used:

The experimenter introduced the series of conservation tasks by saying "We are going to play a game with these glasses and this colored water. First, I will pour the same amount of water into both of these glasses, both yours and mine." As the experimenter was giving instructions, he or she poured equal amounts of water into both identical containers. The experimenter asked the child, "Tell me, do you think that both glasses have the same amount of water?" If the child had any doubt about the equivalence of the colored water in the two identical containers, the experimenter made appropriate adjustments to assure him or her of initial equivalence. When the child was convinced of the equivalence of the identical glasses, the experimenter asked the child to watch very carefully while he or she poured the water from one identical glass into an alternate glass, either the tall, narrow container or the short, wide container. The experimenter asked the conservation of liquid question, "Does this glass have the same amount of water as that glass, or does one glass have more water?" The child's judgment was followed by the inquiry, "What makes you know?" or "How can you tell?" The child's explanation terminated the trial; the board was cleared; and a new trial was begun.

APPENDIX E

PROCEDURE FOR THE HIGH OPERATIVE CUES EXPERIENCE

In order to establish initial equivalence or nonequivalence in the rows for number conservation, the child was given one cube at a time and asked to put them in a straight row. The experimenter took one cube for himself every time he gave a cube to the child and made a row parallel to the child's row. When both rows were completed, the experimenter asked, "Are there the same number of cubes in your row and in my row or does one row have more?" With a correct response from the child, one of the two rows was transformed by the child according to instructions given by the experimenter. As in the other groups, in order to prevent response stereotypy, the presentation of trials followed a counterbalanced order of the arrays appearing in Table 1. The experimenter guided the child's manipulation of the cubes in extending the variable row with the following demonstration and instructions: "O.K., (child's name), I would like for you to make this row of blocks longer for me by spreading the blocks out. You can start by putting this block right here." As the above directions were being given, the experimenter took a cube from one end of the variable row and placed it in a position marking one extreme boundary of the longer, transformed row. When the experimenter was certain that the child had observed the demonstration of the boundary, he replaced the cube in its

original position and asked the child to perform the elongation of the row. The transformation of the compressed row was guided by these directions and demonstrations: "Now, (child's name), I want you to make this row shorter for me by moving the blocks closer together. You can start by moving this clock to here, like this. You would move the blocks on the other end toward the middle about the same distance." Once more the experimenter demonstrated one of the shortened boundaries with one of the end cubes and asked the child to move the blocks together to shorten the row. The experimenter provided assistance verbally in aligning the reconstructed row and establishing approximately equal distances between the cubes. When the transformation was complete, he or she posed the conservation of number question, "Do both rows have the same number of blocks, or does one row have more?" When the judgment had been made, the child's explanation was elicited. If both responses (judgment and explanation) were adequate, the experimenter reinforced the child's answer with a gummed paper star and the repetition of the child's accurate response. If either or both of the child's responses were incorrect, then the experimenter's feedback to him consisted of a verbal rule including the notions of equivalence, reversibility, and addition or subtraction as logical explanations. The rule was stated as follows: "There are the same number of blocks in both rows even after you moved one row because they are the same blocks we used to build the first two rows; if you move the blocks back the way they were at first, the rows still will have the same number (or for the trials with unequal rows, "this row still will have one more block"). You didn't add any blocks or take any away when you moved them, did you?" After the rule was given, the experimenter asked

the child to put the cubes back the way they were before they were moved. The experimenter commented then, "See, the rows are just like we first built them." The verbal rule instruction provided experience in concrete operational reasoning. Putting the cubes back into the original array provided sensorimotor experience with the principle of reversibility which Piaget asserts is essential for true conservation. The entire board was cleared of cubes at the end of each trial. A new trial began by asking the child to build another row as the experimenter built his or her own.

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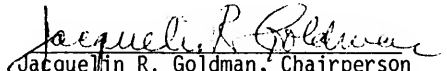
BIOGRAPHICAL SKETCH

Charles Russell Clifton, Jr. was born on July 17, 1946, in Atlanta, Georgia. Most of his first eighteen years were lived in Atlanta and in Newnan, Georgia. He graduated from Newnan High School in 1964. His undergraduate education occurred at Furman University in Greenville, South Carolina, where he majored in psychology and minored in English. His Bachelor of Arts degree was conferred in June, 1968.

In September of that same year, he entered the University of Florida to pursue graduate work in psychology. He received the Master of Arts degree in March, 1972, and the Doctor of Philosophy degree in December, 1976. During the course of his graduate study, he was a trainee of the National Science Foundation, an intern at Shands Teaching Hospital and Clinics and at the Psychological and Vocational Counseling Center, and Coordinator of the Alachua Area Children's Program for the North Central Florida Community Mental Health Center.

He is married to the former Sandra Diane Chappell of Gainesville, Florida, and has a daughter, Ashley Brooke, age 3 years, and a son, Joshua Dowis, age 4 months.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


Jacquelin R. Goldman, Chairperson
Professor of Clinical Psychology

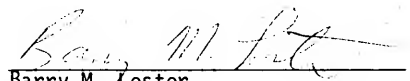
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Harry A. Grater
Professor of Psychology

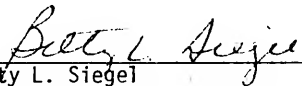
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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.


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Professor of Education

This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1976

Dean, Graduate School

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